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The Abuse of Cost Data.

A contractor of many years' experience on large work, whose father and grandfather before him had also been contractors, recently declared publicly that if a man could prognosticate accurately the cost of proposed construction undertakings, that man could command remuneration which would soon make him a prince even among the very wealthy. In the same connection it was also affirmed by more than one man of wide experience that it was absolutely impossible for any man to tell the cost of any large proposed engineering work until it was completed, and even then it was not always possible to determine the cost accurately in detail. Such statements doubtless will at once excite the interrogatory convolution of the brain of many a younger member of the profession, and of some also who can count some score of years since first they carried the rod. In these days there is a growing tendency in some quarters to place dependence upon cost analysis methods and records of cost data, to an unwarranted degree.

As a commentary upon methods of making estimates for proposed civil engineering works the testimony presented at hearings concerning the Ashokan dam contract now in progress in New York City has more than passing interest. As explained in some detail last week in The Engineering Record, this contract was awarded on the basis of unit prices and the engineers' estimated quantities to a bidder whose tender was about two and a third million dollars higher than the lowest bid. Although within the clearly prescribed power of the Board and by no means an unprecedented act in principle, the award elicited criticism from local newspapers, and in course of time the investigation now progressing was instituted by the Commissioners of Accounts. Investigations are an inevitable and necessary feature of public affairs, and their value in showing good as well as bad administration is important, provided the examination is a fair one. That the present investigation of the Board of Water Supply is proceeding along questionable lines seems to be the opinion of those who have attended the meetings and do not judge the testimony from the incomplete newspaper reports solely.

The engineers of the Board believe that the lowest bid was much below the reasonable probable cost of the work, and the investigation practically hinges on the value to be placed on their judgment. The Board held that the low tender of the lowest bidder and its inexperience in the class of work covered by the contract, consisting largely of rolled earth embankments for large dams, was deemed sufficient reason for the award made to a higher bidder, for records of many cases under similar circumstances showed that delay, additional expense and much other trouble had resulted from giving the contract to the lowest of all the responsible bidders. The construction of the dams within the time stipulated in the contract is highly important, because the additional water is urgently needed by the city. The president of the company which made the lowest bid, who was abroad at the time of the bidding, subsequently stated that he believed his tender was too low, but his engineer stood by his figures and testified that he estimated there would be something over two million dollars gross profits.

Quite naturally the technical features of the controversy hinge upon the ability of engineers and contractors to estimate with some degree of accuracy the cost of large works extending over a period of years; there may be political considerations back of the investigation that have not yet been made public. The three engineers hired by the Commissioners of Accounts to help them in the investigation are strong advocates of the cost-analysis method of estimating. On the contrary, the chief engineer of the Board testified that he believed published cost data, with their usual meagre statements of conditions, were exceedingly unreliable bases for important estimates. For work like that under discussion, he could make a safe estimate only by exercise of judgment trained by his long experience in this class of work, guided by a knowledge of the total unit costs of the most important items, gained from completed works with which he had been personally connected or with which he had intimate knowledge. He further testified that he had made many estimates of the cost of work in this way which had been closely confirmed by the actual total cost of the work when completed.

According to testimony during the investigation, the lowest bidder's estimate seems to have been made by one engineer and to have been merely reviewed by two other persons, one of whom checked it by aid of published cost data. In sharp contrast were the methods of the second bidder to whom the contract was given. Great care was exercised to have the work studied thoroughly, but quite independently, by several members of the associated concerns and their engineers, one of whom was specially retained for this purpose. On the fourth day prior to the date for receiving bids by the Water Board, a meeting of these parties was held and six independent bids submitted to the president of the company, just as if he were to award the contract. All of these bids were higher than the bid finally submitted to the Board. Then followed a discussion, with very brief interruptions for sleep and food, lasting until the morning of the day for depositing the bids. The reduction made in the final bid, as compared with the preliminary estimates, was determined upon principally because the company had over a million dollars' worth of suitable plant immediately available. The successful bidders testified that they had used only records of cost of completed works done by themselves or with which they had been connected, comparable to the work in hand, and that even these records had been applied with very careful exercise of judgment after learning as much as possible of the conditions surrounding the proposed work.

Altogther much testimony of a very positive tone was given by men of great experience as engineers and contractors as to the great hazard in using published cost data or similar information borrowed from other persons unless one had thorough personal knowledge of the works to which the information referred. Only the contractor, except in rare cases, can know the total cost of completed undertakings, and he frequently does not keep sufficiently complete records to permit detailed analysis of unit costs. Much less can a young engineer or inspector, by occasional observations or daily force account records, get at the real cost of the items of any large work on which he may be engaged, although he has the closest personal contact with it. There are a number of elements of cost, large in the aggregate, that cannot be detected by such observation. Contractors bid on much work which they do not get; it frequently costs thousands of dollars to prepare a safe bid on a large undertaking. At least a small nucleus of an organization has to be kept constantly, whether there is much business or little in the office, for such men are selected largely for compatibility and other personal qualities and cannot be easily replaced. Interest on deferred payments and on investment in plant, insurance of men and plant, losses due to delays or failures of supply dealers, and accidents must all be covered. And there are many other elusive factors in the total cost. To these must be added the so-called general office and administration expenses of the particular work. In view of these facts, refined analysis of the cost of labor and materials for masonry or earth work, for example, when labor and materials constitute but fifty to seventy per cent. of the total, is of questionable service, since the remaining and large element of the price to be used in the bid or estimate is not susceptible of close determination and is inevitably a matter of judgment, in large part.

The gathering of information about the cost of engineering works in detail is to be encouraged, but the notes must contain very complete statements of conditions if they are to be used for estimating the cost of proposed construction. The likelihood is that, after all, they will be safely useful only to the men connected with the work on which they were made. In many lines of manufacturing and in a few kinds of engineering, the cost in detail of the various processes or acts entering into the finished product can be determined, by suitable records, with all necessary accuracy; but the number of dips a minute a steam shovel can make may have very little to do with the rate of progress or the cost of a large job of excavating, and the number of feet a minute a steam roller can travel may have still less to do with the cost of a large rolled earth dam. Such information is useful for the suggestions it gives concerning methods of increasing the efficiency of a working force, but it should no more enter into estimates of the cost of great undertakings like the Ashokan dam and dykes than the cost of lead pencils should be considered in the expense of preparing the plans for such works.

Improved Waterways.

The cry that is going up from most parts of the country for improved waterways would indicate that there are a number of people who must have water on the brain. If the history of means of transportation teaches anything it is that waterways are unexpectedly costly to construct and peculiarly uncertain as to returns. Those who talk so glibly about constructing canals and improving rivers at the public expense in order to supply competition to railways, overlook the fact that the railway has one tremendous advantage. It can overcome grades and force itself across country in a way that no canal possibly can. The grades that are possible for a canal are necessarily flat, it is often extremely difficult to provide locks where they are most needed, and in some cases the problem of supplying enough water for navigation has itself proved an insuperable obstacle to construction. Then, again, when the waterway has been completed it is unsuited for handling anything but slow freight. It is out of the question to make fast time on such narrow channels; even if boats are put upon them which have the power to make good speed, the wash they set up is so great that the banks are severely injured. On wide rivers this condition does not exist, but there is a limit to speed there which is set by the necessity of providing enough cargo space to make the boat pay a profit. This condition has practically done away with the old river packet which made fast time, and it is only in a few localities, where the travel is large in volume and can be done at night, that boats can hold their own for transporting passengers in competition with railways. The internal waterways problem is, therefore, essentially one of transporting freight, and must be approached from this point of view.

A great deal has been said about the competition which waterways will offer to railroads. This really seems more theoretical than actual. The trunk line railroads to-day are hard pressed to handle their business, at least those lines which would be, in a sense, paralleled by improved waterways. If much more business comes to them they will have to spend enormous sums for further improvements. It seems to be the general belief among railway men at the present time that what is most needed is the improvement of existing facilities, more side tracks on single-track lines, better terminals, the elimination of dangerous grade crossings, improved rolling stock, and things of this nature. Such improvements will enable the roads to take care of all the high-grade freight requiring fast movement that is likely to come for some time. The increase in this kind of freight seems likely to be steady. If waterways can be constructed which will handle the low-rate bulk freight which is actually a burden on some roads, so much the better for the lines in question. Leading railway officers unquestionably express their full belief, without reservation, when they endorse reasonable projects for internal navigation improvements, as they have done with practical unanimity during recent years.

Although these internal waterways can be considered only as partial competitors of railroads, and their merits on that score are problematical, they nevertheless have such important advantages as to merit the attention they are receiving from those who are approaching the subject from a sane point of view. The construction of an improved waterway is like any other transportation problem. It is necessary to look far into the future, to estimate the growth of the population in all the regions tributary to this waterway, to forsee the character of the products which will be produced there and the nature of the goods which must be imported into this region. It is necessary to study the types of vessels which seem likely to be suited for carrying freight on the waterway. Finally, it is necessary to go into the cost of the proposed work in careful detail, in order that the expense of providing the waterway may be fully understood before any work is done. When a project is approached in this thorough manner, it becomes one of such complication that most of the advocates of improvements of this nature either lose heart or are contented to deal in mere generalities. Most of the agitation which is being conducted at the present time has reached this stage. It is now a matter of either hard work or hot air. The Engineering Record is a sufficient believer in the value of improved waterways to hope that hard work will be done. We really know very little, speaking generally, in this country, concerning the important details of improved waterways, vessels best suited to navigate them, and such technical matters. Whatever work of this sort is done should be conducted, in most cases, by the Government, and this journal believes that Congress would do well to give the Chief of Engineers, U. S. A., an ample appropriation for a thorough investigation of the problem. This would require capable assistants, some of whom would have to make careful studies in Europe, and it would entail several years of investigation. The importance of the result, however, fully warrants the expenditure. Without some such thorough investigation, we are all groping in the dark at the present time.

The Evolution of Interurban Lines.

The growth of electric interurban lines in the last ten years has been of the most extraordinary character. Starting as mere extensions of urban lines, the electric roads felt their way out into the suburbs and then, growing bolder, began to take up the work of ordinary railways. There has been no sudden creation of an interurban species; it has developed by orderly evolution into what it is. A road which went into operation about a month ago, the Milwaukee Northern, is an excellent example both of the resulting product and of the variations which, unless suppressed by natural selection, may form a further stage of the evolutionary process.

To begin with, the road has reached out northward from Milwaukee about 30 miles and extensions are in prospect that will carry this distance to more than 100 miles. The country thereabouts is, as everyone knows, rich in small cities and large towns capable of giving large local and through traffic, just such a country, in fact, as twenty years ago would have tempted the capitalist to the construction of another steam railway line. To-day the motive power is changed, but in other respects the work has gone on by the usual methods of railroading. In other words the time has come when, given the economic need for a railway, it is built up to the proper standards of construction and the motive power is chosen on its merits.

The Milwaukee Northern owns its right of way, save in passing through cities, and has put in a good straightforward piece of railway construction, differing in no essential features from the standards of the best steam railway practice. It has a solid, well-ballasted roadbed, laid with standard 70-lb. rails in the main, and has kept rigorously to low curvature and low grades. The day has past when electric railway builders went in for sharp curves and 10 per cent. grades just to show that the motor cars could negotiate them. There is, too, a general absence of grade crossings and all the difficulties they entail. The electric construction along the line presents nothing out of the ordinary.

The most striking feature of the road is its power station at Port Washington. It is the first considerable electric plant for railway purposes worked with gas engines and producer gas —indeed the only large one which relies solely on this source of power. The only other gas engine railway stations are the Warren & Jamestown plant and the auxiliary stations of the Boston Elevated Railway, and these are not only much smaller than the Port Washington station but are not essential features of the Boston system. Indeed, from all accounts, it is rather likely that the latter are considered unimportant, for, while fairly successful, it has been no small task to get them into working condition, and there are no symptoms of any increase in capacity of this particular kind. The Port Washington station has its experience yet to acquire, and it is to be hoped that it will be altogether satisfactory. The plant consists of three 1,000-kw. Allis-Chalmers generating sets, designed for a large over-load capacity.

The engines are of the twin tandem horizontal double-acting type, with an ultimate capacity of more than 2,000 h.-p. each. One of them was described in the Current New Supplement of this journal on Aug. 24 of this year. The cylinders are 32x42 in., and operate at 107 r.p.m. The engine frames are arranged for side cranks instead of double throw cranks, a plan very unusual for large gas engines. These engines are supplied with gas from two Loomis-Pettibone units, each including a pair of producers with their accessories and rated at 2,000 h.p. per unit. The coal employed is Hocking Valley bituminous slack, having a thermal value of about 11,500 B.t.u. per pound. The resulting gas as drawn from the holders is of about 125 B.t.u. It is claimed that the producing system delivers in the gas 80 per cent. of the thermal value of the coal. If this figure is substantiated, it puts the producer on a considerably higher plane than the steam boiler as a thermal intermediary between fuel and engine.

No details of engine performance are yet available. Experience with big gas engines in this country has been quite varied, but upon the whole fairly encouraging. The opinions of engineers are much divided, some holding that gas engines are the coming motive power and others that they are uneconomical unless waste gases are available. Abroad a good degree of success seems to have been the rule, and the number of installations now going in on our own side of the sea shows that confidence is not wholly lacking here. Yet there is a singular lack of definite data from American practice, which gives one a certain feeling of insecurity. Recent steam turbine performances have come so near to the best gas engine figures for fuel consumption per kilowatt-hour as to leave very little room for difference in fixed charges and maintenance as against the gas engine. It is to be hoped that figures from this big new plant will soon be available to show whether the gas contingent has been able to peg up the record a notch.

The Milwaukee Northern is doing by electric traction and from a gas-driven generating plant the regular work of the older steam railroad, and so far as all appearances indicate it is doing it better. Certainly it is doing it better from the standpoint of the patron, since the highest cash fare is but 2 cents per mile and mileage books bring the rate down to 1.3 cents per mile. An interesting feature of the traffic situation is that under the franchise provisions the Milwaukee Northern is obliged to sell eight tickets for 25 cents, good within the city limits. Cash fares are 5 cents, as usual. Now the company runs its city cars about a mile beyond the city limits and it has promptly toed the mark by making these tickets good for the whole city-car service, which extends to 4.3 miles. This comes pretty near to a record low fare and it certainly is enough to give a steam railway man the cold shivers. Of course the proposition is not so formidable as it looks. There are at present but four strictly city cars in service and the through cars can be depended upon to show ample earnings. It has often been the experience on interurban lines that the near suburban and urban work amounts to very little, and on a road like the present, with a long run and good population along it, the lowered fare within the city should cut a comparatively small figure in the balance sheet. As far as American data go eight tickets for a quarter is a figure just too low to be practicable even for strictly city work. Fortunately the Milwaukee Northern is unlikely to suffer much from this cause and has ample traffic in sight.

Working Stresses for Long Span Bridges.

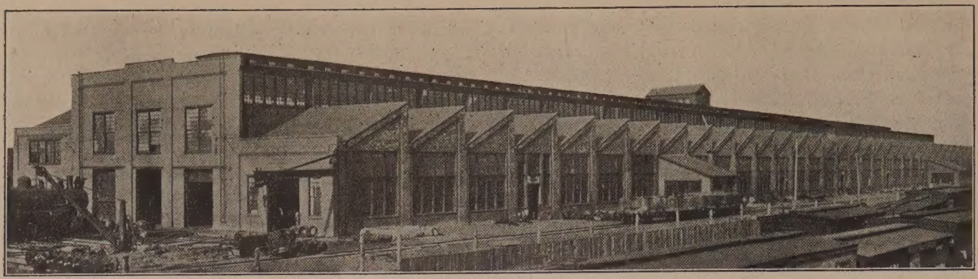
It has never been an easy matter to determine properly the greatest permissible unit stresses in the members of bridges and other structures of moderate spans and ordinary dimensions, to say nothing about those structures of such unusual magnitude as to make that determination still more difficult. The stresses in an ordinary bridge structure for any prescribed moving load are easy to determine with a high degree of accuracy, if the load be considered static, and it is easy to go still further and fix a reasonable allowance for shock or the assumed effect of a rapidly moving load. After having determined these stresses, however, the real difficulty begins. While we may assume the greatest permissible stress per square inch in the material for both tension and compression members, the rational defence of such stresses against reasonable criticism requires far more consideration than at first sight seems necessary.

In the early days of bridge building the greatest working stress was ostensibly one fifth of the ultimate resistance, but that was a technical fiction which quickly disappeared in favor of a so-called safety factor of four; and even this latter value has attached to it considerable doubt. In order that a fractional value of the ultimate resistance of a member of a structure may acquire significance, that ultimate resistance must be known. There has been almost an endless number of tests of eye-bar tension members, but almost none at all of steel compression members or columns. As a matter of fact, the tests of eye-bars, even those up to 15 in. in width, and of other tension pieces, have disclosed fairly full and accurate knowledge of this class of structural members, showing that one-fourth of their ultimate resisting capacity is generally materially less than the allowed working stress. This difference, however, is not of great importance, a sufficient margin of safety existing in any event, but the case is radically different when compression members, as well as some important details are involved. So much investigating attention has been devoted to the testing of tension members that it has been quite forgotten that we know comparatively little about the ultimate carrying capacity of both upper chord sections and intermediate and end posts of the ordinary truss bridge. The failure of the great compression members of the Quebec bridge has directed public attention so intensely to this whole matter of the carrying power of built columns that experimental investigation as to this particular feature of design is likely soon to develop results of the highest value. In the meantime, nobody actually knows what safety factor exists in the built columns of any railroad bridge, even of moderate span. It is reasonably certain that the actual carrying power of these members, instead of being four times the greatest load coming upon them, is somewhat less, and possibly it does not exceed three times the actual load carried in some cases.

While these observations are directly pertinent to short-span bridges they bear with special force on the design of long-span structures. This arises from a number of causes. In the first place, the magnitude of the members required for a great bridge truss so far exceeds that of the ordinary bridge member that it is an open question whether inferences as to actual carrying capacity can be accurately drawn from tests of small sections for the larger. It is generally assumed that such inferences may safely be drawn, and that process seems reasonable. At the same time every thoughtful engineer who has this duty to perform frequently reflects most seriously whether, after all, he is proceeding along lines which can be effectively defended. And this statement is made entirely without reference to the fact that the elastic and other physical properties of the thick metal and heavy shapes and plates of the long-span pieces justify materially less working stresses than the thinner and lighter sections of short-span structures. This latter consideration is probably never permitted to affect the value of long-span working stresses, although probably no test of full-size structural pieces ever failed to indicate its importance. If a testing machine of great capacity ever becomes available for tests of compression members of comparatively great area of section, the importance of this feature of heavy section design will be fully recognized.

On the other hand, it is obvious that the long-span structure is far less likely to receive frequently its full loading than the short-span bridges. This condition in itself justifies the use of higher working stresses than would be permissible for a bridge whose length is so short as to cause its maximum loading possibly many times a day. While this is clear enough, it is not sufficiently obvious just how far the influence of this condition may be permitted to reach.. This, like many other highly important engineering questions, must rest wholly upon the judgment of the responsible engineer. The prevailing practice in the past, both in completed structures and in the design of some great projects not actually executed, appears to indicate that no main piece of any long-span structure should, under any conditions of loading whatever, be stressed more than one-third of its ultimate carrying capacity. When the many exigencies of manufacture, erection and use after completion are kept in view, such a limit certainly does not provide more than reasonable safety. When it is further reflected that engineers at the present day really possess little exact knowledge of the actual carrying capacity of one of the great classes of bridge members, the danger of adopting a working stress of but little less than half what may reasonably be anticipated to be the ultimate resistance can be appreciated, especially when one large element of the moving load is entirely neglected. Some fundamentals of long-span working stresses require most careful consideration and re-statement, and there is need of further experimental investigation as to the carrying capacity of large compression members.

THE NEW YORK SUBWAY report, which Mr. B. J. Arnold submitted to the Public Service Commission, is a particularly interesting document to the engineer. The subway trains are now jammed full of people during rush hours, and from time to time assertions are made that this crush is due to defective engineering work in designing the road or to negligence of the operating company to run enough trains of enough cars to handle the traffic. When the Public Service Commission assumed office and first investigated subway conditions, it decided that more cars were needed and directed the Interborough officials to buy them. When it was discovered that the company had already ordered these cars some months before the Commission was appointed, the latter body recognized that the problem was a pretty big one. It accordingly determined to supplement the advice of its own engineers with the counsel of Mr. Arnold, whose long study of intricate transportation problems in Chicago made him particularly fitted for such duties. In his preliminary report, printed on another page of this issue, he has nothing but praise for the subway and its operation, a decision to be expected but none the less gratifying as the judgment of a well-qualified critic never before connected with the enterprise in any way. The subway has almost reached the limits of its capacity, and the problem of carrying more people in it is one of policy and not of engineering. This journal believes that very rarely has an engineer so concisely and clearly demonstrated such a condition. If more people are to be carried, it will be necessary to reduce the number of seats, make more people stand in the cars, and manage the crowds on the station platforms more strictly. The Public Service Commission must accordingly make a serious decision itself, the responsibility for which cannot be delegated to its engineers. It is gratifying to see such a problem put directly into the hands of that body. But the main lesson of the report is that New York greatly needs more rapid transit lines, a fact reiterated many times by those familiar with transportation in the city. The tremendous cost of these roads is such that the city cannot well finance them for some years with its other great obligations, while no terms yet proposed by the city will attract private capital. The problem is a serious one to those who are obliged to struggle to and from their work in the present packed cars, and if the city cannot afford relief it would be wise to allow private capital to build at least one line even if the terms are not so favorable to the city as the municipal authorities desire. The necessities of the public should receive some consideration in discussions of such a complicated problem. At present the crowds on the trains are so great as to offend every sense of public decency.



Main Locomotive Shop, Missouri, Kansas & Texas Ry., Parsons, Kan.

SOME ENGINEERING FEATURES OF THE PARSONS SHOPS OF THE MISSOURI, KANSAS & TEXAS RY.

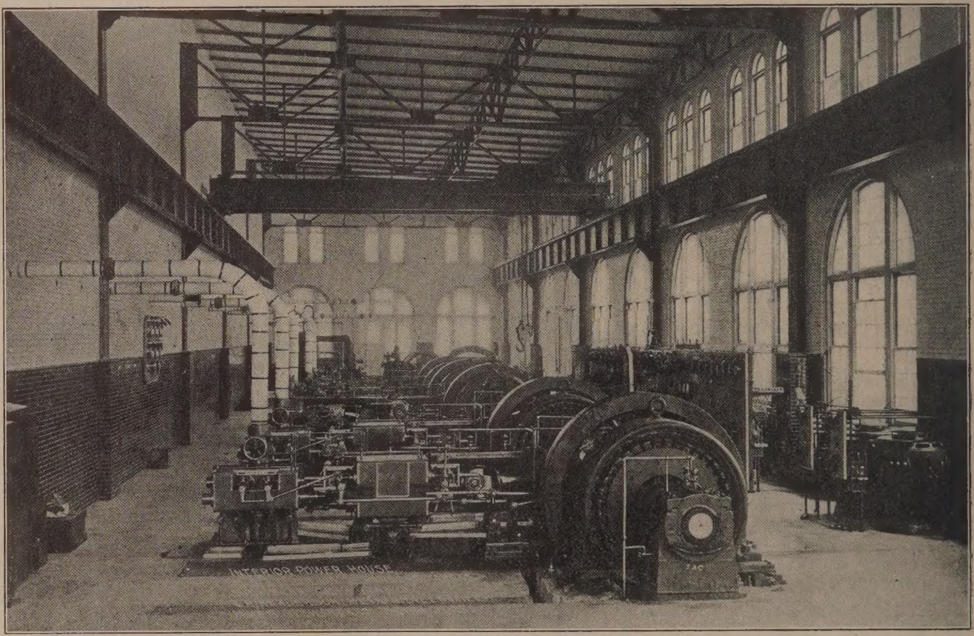
The Missouri, Kansas & Texas Ry. operates over 3,000 miles of track from St. Louis and Kansas City to an important Gulf terminal at Galveston. The company has over 20,000 cars and between 600 and 700 locomotives, the greater part of which is good equipment. Its maintenance is conducted at two small shops in Texas, at the Sedalia car shops and at the locomotive repair shops at Parsons, Kan., a city favorably located for division headquarters of the lines north of Texas. The old shops there became entirely inadequate for their work, and an entire reorganization of plant and methods was ordered. It was decided to locate the new shops on a 30-acre triangular tract close to the old site, so that when the latter was abandoned, the buildings could be utilized to a certain extent at least for car repairs.

The shops provide for the maintenance of all locomotives of the lines north of Texas and also for a limited amount of manufacturing for other departments, together with ample provisions for considerable future growth. There are now operated on these lines between 350 and 400 locomotives, a considerable portion of which are large heavy-powered engines. The repair-work schedule on which the shops were designed provides for a general overhauling of approximately one complete engine per day, together with a considerable amount of manufacturing and auxiliary work. It was decided that this can be accomplished most efficiently in a single large shop building for the dismantling and erecting of both engines and tenders and also for all machine shop work, while a separate building is used for the blacksmith work. The longitudinal pit-track type of erecting shop was chosen as best adapted to the available yard lay-out and best suited to the character of the work to be handled. The improvement scheme does not include a reorganization for the present of the car repair shops of the northern lines, which are located at Sedalia, Mo., but the new organization and power scheme will permit the addition of large car shops without change.

The large main building is a steel structure 860 ft. long with a 78-ft. center bay and two side bays 153 ft. 9 in. wide. The blacksmith shop is a 100x250-ft. steel structure, the power house is 84x215 ft., and the store house and office building, 60x150 ft. There are several small auxiliary buildings, a 500,000-gal. 50x150-ft. water storage reservoir, and a group of fuel oil tanks. The space actually occupied by the entire shop group is 450x1,300 ft. over all, which is exceptionally small for a plant of this capacity. The longitudinal track arrangement of the main shop simplifies the yard lay-out considerably, the total length of yard track devoted to shop purposes amounting to only a little over 3,000 ft.

Fire Protection.—The building layout has been studied with considerable care for fire-protection and provisions made for dealing with a fire very effectively before the city fire apparatus arrives. Direct pressure in the mains is furnished by pumps in the power house drawing from the city works, with the 500,000-gal. reservoir in reserve, and delivering through 8-in. mains encircling the shop group, with hose reels within the buildings and hydrants and hose houses distributed over the yard. Local fire signals have been arranged and provisions made for quickly raising the pressure in the mains. Fire roadways run throughout the yard surrounding the main building and lead to all large hydrants having steamer nozzles, to enable the city fire engines to be put in action rapidly. Special orders are given the yard crews to keep these roadways always clear of cars.

There are 18x10x12-in. Fairbanks-Morse duplex steam pumps in the engine room of the power house. The main source of water is an 8-in. metered service to a 10-in. city main leading to the reservoir, and there is also a suction connection to the reservoir. The suction main is 16 in. in diameter and has a by-pass to the 12-in. pump discharge to permit admitting city water into the shop mains in case it is desired to shut down the pumps. One pump is always kept in operation on the shop service, being fitted with a Fisher governor set to maintain the water pressure at 100 lb. The other pump is fully connected up and kept with its throttle valve open a mere crack. By this arrangement the pumps will continue in motion very slowly, but at such a rate as to insure their being kept hot and always ready for instant service. In case of fire the throttle on the second pump is opened and the governor disconnected from the first, allowing both pumps to furnish their maximum pressure.

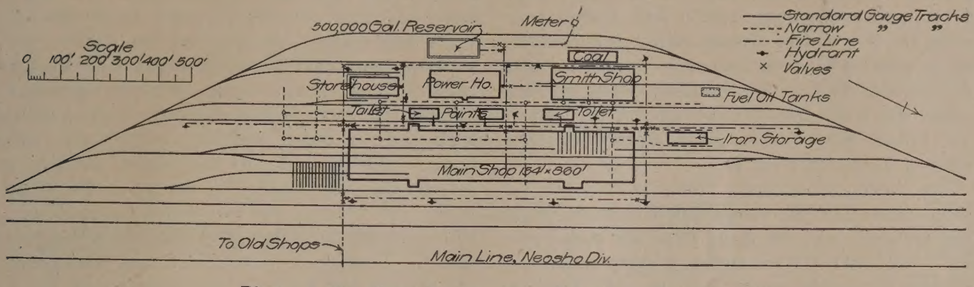


Engine Room of the Power Plant at the Parsons Shops.

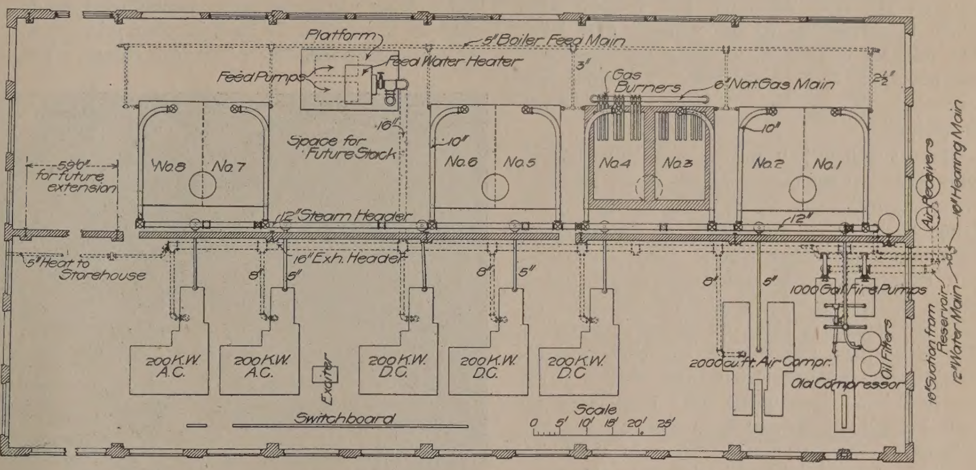
The pumps discharge into the yard mains through a 12-in. pipe which connects about 50 ft. from the power house with a 10-in. main that feeds three longitudinal 8-in. service mains, one on either side of the main shop, and the other at the rear of the blacksmith shop, the power house and the store house. The central 8-in. line is extended several hundred feet beyond each end of the main building and all three lines are cross-connected at each end of the large shop. From the southerly end of the system a 6-in. connection is extended across the yard to connect with the water system of the round house and old shops, which are now to be used for car repair work only. There are sixteen hydrants installed along the line of the fire roadways to the yard, eight of which are plain two-way hydrants for hose while each of the remainder have two 2½-in. hose nozzles and one 4-in. steamer nozzle.

Heating.—The buildings are heated with low-pressure exhaust steam from the power plant, supplemented by live steam at reduced pressure, when necessary, with hot-blast heating in the main locomotive shop and direct radiation in the store house, office building and auxiliary buildings. The heating requirements are, however, comparatively moderate at Parsons owing to its southerly location, for which reason no direct radiation was installed in the main shop or in the blacksmith shop, and, in fact, no heating of any kind was provided in the latter shop for service in the daytime owing to the warmth from the forges and furnaces; in this building a limited amount of heating is provided for use at nighttime and on holidays, to prevent freezing in severe weather, by diverting the hot blast delivery from one of the heating stands of the main shop. The low-pressure steam supply is distributed by mains through the underground piping tunnels which connect the power house to various buildings, a 5-in. heating main extending from the exhaust header in the power plant to the store-house and office building and a 16-in. main to the main locomotive shop building.

The main shop is served by four separate hot blast equipments. The blowers and heaters are of unusual size, and located in 20x26-ft. fan houses outside the walls of the building, there being two on each side at quarter points of the building. These houses open directly into the main shop, from which the fans draw their air; large windows are provided to supply fresh air when it is desired to run the fans for ventilation during hot weather. Sturtevant steel plate centrifugal fans are used with three-fourth downward discharge housings and 9-ft. wheels 44 in. in width. Each is direct-driven by a 9x12-in. Sturtevant horizontal engine running at 180 r.p.m, at which speed the blower has a capacity of 57,000 cu. ft. per minute. Each engine receives steam through a 3-in. connection to the high pressure pipe from the power house and exhausts through a 3½-in. connection directly into the main which supplies low pressure steam to the heating stack. There is also an auxiliary 3½-in. connection for carrying the exhaust from the engines to the outside in case it is desired to operate the engine when heating is not required. The heating stacks are located in 10x12-ft. casings connecting with the fan intakes and each consists of four sections of Sturtevant heaters, containing 8,000 lin. ft. of 1-in. pipe.

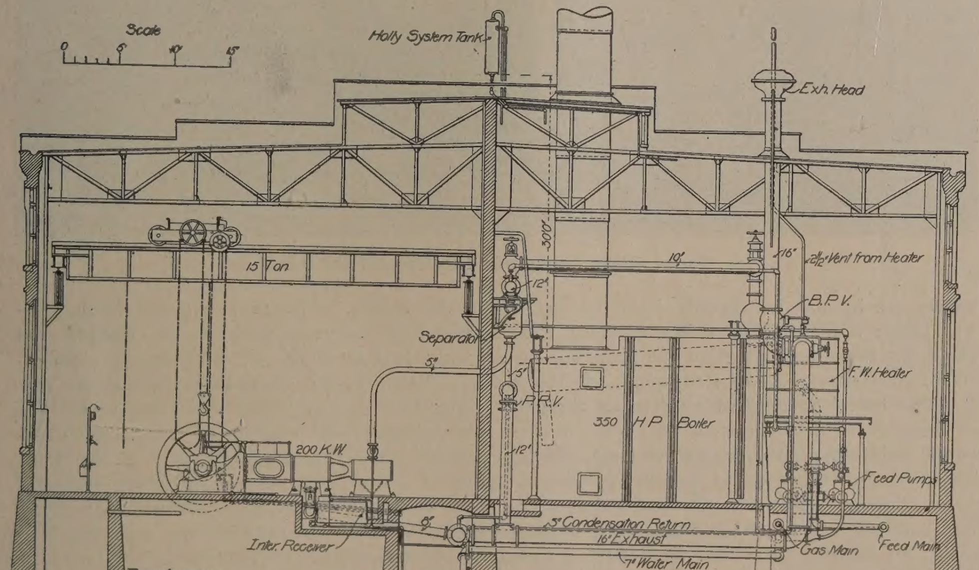


Plan of the New Locomotive Shops at Parsons.



Plan of the Power Plant at Parsons.

The hot blast is distributed through concrete trunk ducts from 36x40-in. to 20x20 in., running longitudinally under the floor within the rows of crane girder columns which extend approximately one-half the length of the shop building. Midway in its length each duct is connected with its blower by a concrete cross-duct under the side bay floor. These cross ducts are 4½ ft. square. The longitudinal ducts have 15x24-in. outlet connections alongside each crane column which supply the hot air duct risers. Galvanized ducts 20 in. square carry the air from the outlet branches to elbows which discharge horizontally about 10 ft. above the floor level. There are seventeen outlets supplied from each fan on the south side of the building and fourteen from each fan on the north side. The duct velocities are figured high for the cross and trunk ducts, averaging about 2,000 ft. per minute, but are reduced in the branch and outlet connections approximately 1,200 to 1,500 ft. per minute at the outlet elbows.



Cross Section of the Power House, Showing Pipe Systems.

Provision is made for diverting the discharge of the blower at the corner of the building opposite the blacksmith shop into the latter building for heating nights and on holidays when the forges and furnaces are not in operation. As at such times only partial heating is required in any of the buildings, it was figured that the hot blast delivery from this fan could well be diverted from the main shop to the blacksmith shop. For this purpose there is a full-size branch from the delivery duct from this blower to the blacksmith shop, where the underground duct connects with a 40-in. circular galvanized iron duct that rises within the building to a horizontal distributing duct 18 ft. above the floor level, which has five 20-in. horizontal outlets. No other heating arrangement is provided for this shop, as before stated. The hot air from the forges and furnaces is allowed to rise directly into the building without exhaust hoods. Smoke is removed by two 48-in. disc exhaust fans one in each end of the roof monitor, which are direct-driven by 3½ h.p. motors. Each fan is rated at 16,000 cu. ft. of air per minute.

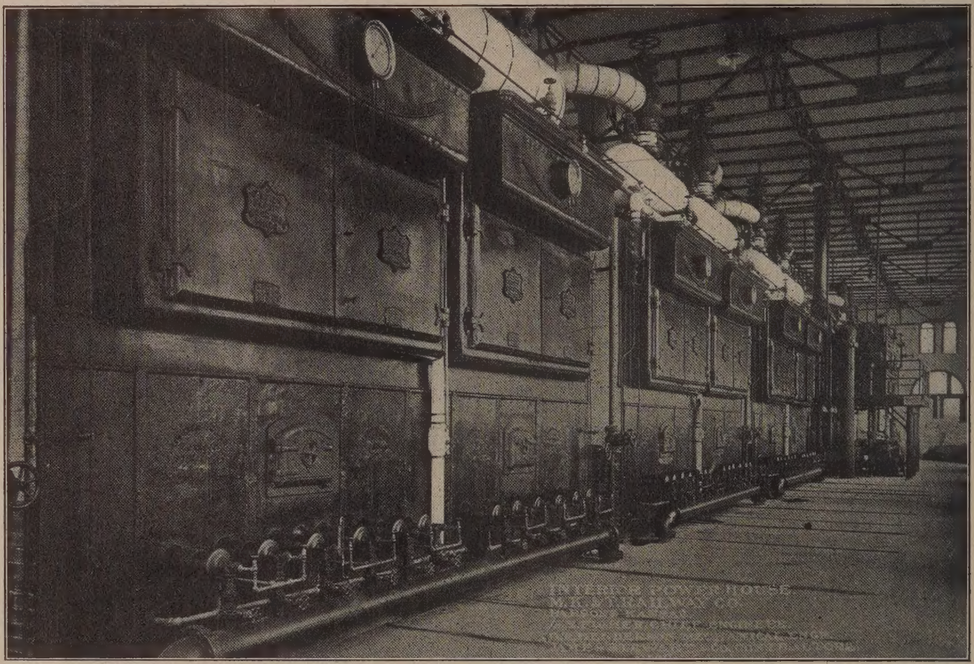
A small amount of heating is also required in an oil-tank pit in the yard, in which fuel oil for the smith shop forges is stored. Owing to the underwriters' requirements, the tanks were located 200 ft. from the nearest building, and depressed below grade in a concrete pit, 14x34½ ft. in interior dimensions and about 8 ft. deep. There are two 6½x27-ft. cylindrical steel tanks, each of 4,000-gal. capacity, for the main storage and two 33-in. x 8½-ft. cylindrical steel pressure tanks, containing 350 gal. each, from which the oil is forced pneumatically to the shop. In order that the oil, which is a cheap grade of heavy fuel oil, may flow freely, the pit and the conduit carrying the piping have a 1¼-in. heating line from the high pressure heating main. Two coil radiators are used, one of 116 lin. ft. of 1¼-in. pipe between the large pair of tanks and the other of 52 lin. ft. between the small pressure tanks. As the pit has a wooden roof with tar and gravel covering about 10 in. above grade, the oil is easily kept at moderately high temperature and its fluidity is maintained in the conduit by the uncovered steam supply line. There is no return line, the condensation being discharged by a Geipel steam trap into a drain. For underground pipe lines, sectional tile conduit 8 in. in diameter was used, which carries a 2-in. oil line and 1¼-in. steam and air lines, the pipes being supported on expansion rollers spaced 11 ft. apart.

Power Plant.—The shop group has been centered around the power plant which has sufficient capacity to provide power for the new locomotive shop and also for the car repair shop, with room for increase. The station takes care of the heating and lighting of the buildings, furnishes power for all the machinery driven electrically or pneumatically, and furnishes current for lighting the yard. The location of the power house was determined almost wholly by the center of power consumption, which lies near the center of the main locomotive shop building; the lighting of the yards and buildings in all portions of the property is done by high voltage circuits and thus does not affect the power house location. The site chosen is convenient for obtaining both fuel and water supplies and the piping and wiring to the buildings are carried in subways, so located as not to be affected by future extensions.

The plans of the station were drawn for an 84x215-ft. structure to accommodate a contemplated plant of a capacity represented by a total of 3,000 boiler horse-power, but only a portion of the equipment has yet been installed. There are now five electrical units of a total capacity of 1,000 kw., two air compressors together capable of compressing 3,000 cu. ft. of free air per minute and four batteries of boilers having a combined rating of 2,000 h.p. The building is laid out with longitudinal boiler and engine rooms, capable of extension on either end, with a longitudinal wall through the center dividing it into boiler and engine rooms of equal width. Both the rooms have their floors 6 in. above the surrounding grade as are those of the other shop buildings, and in both there is a clear head-room under roof trusses of 26½ ft. A basement with 10-ft. head-room has been excavated under both boiler and engine rooms, surrounding the boiler and machinery foundations, in which piping connections and a considerable amount of auxiliary machinery are located. The building has a ferroinclave reinforced concrete roof covered with four plies of tarred felt laid in roofing pitch and covered with gravel. This roof is carried by steel roof trusses on 29½-ft. centers. These trusses on either side of the building have monitors on the ends adjoining the division wall, which is carried up to the monitor roof level. The monitor is 12½ ft. in width on either side and has 30-in. sash on the sides. The floor construction is of concrete with cement mortar finish throughout.

There are four batteries of water-tube boilers, with space left for two more, which are arranged along the inner side of the room facing a 15-ft. firing floor on the outer side, to permit ample lighting on the boiler fronts. Each battery of two boilers is 25 ft. wide. There are 4½-ft. spaces between them and a 3½-ft. space at the rear for steam and blow-off piping connections. The boiler room arrangement and equipment are considerably simplified by the use of natural gas for fuel, but arrangements have been made for handling and storing coal in case the gas becomes exhausted. The structural feature of the building are so arranged that elevated coal bunkers may be built over the firing floor, and space has been left in the roof and basement for installing a coal and ashes conveyor. The lower run of this conveyor would pass close to the outlet doors of the boiler ash pits which open into the basement and would raise the ashes to an elevated pocket, while coal would be raised from a basement receiving hopper to the bunkers. An opening has been left in the outer wall of this basement to permit constructing such a hopper under the coal siding alongside the boiler room, with crusher and auxiliary conveyor for delivering the fuel to the main conveyor. Short steel stacks are all that are needed while gas is used, but a tall brick stack to serve all boilers will be built if coal is used. A 58-in. steel stack is now used for each battery; these are supported on the rear of the boiler fittings and rise to a height of 60½ ft. above the boiler room floor.

Sectional water-tube boilers of the Heine make are employed, each rated at 250 h.p. Each has two 36-in. x 22½-ft. steam drums parallel to the tubes and a heating surface of 140 4-in. tubes, 18½ ft. in length which are expanded into wrought steel water legs which are riveted to the steam drums. Each drum is connected through 10-in. nozzles into a 30-in. steel cross drum 8 ft. long above the boiler front which carries two 6-in. safety valves and the main 10-in. steam nozzle. The boilers are hung free of the settings by link suspensions from two pairs of 15-in. I-beams which span the front and rear of the settings. The settings are 20-in. thick at the sides and 22-in. between boilers. They are carried on concrete foundations having ash-pits at the front which slope toward the special outlet doors through which ashes may be scraped out on the proposed conveyor. At present however, the ash pits and furnaces are closed with a fire-brick floor at the future grate level and in this flooring are nine openings about 5½ ft. in length in which the natural gas burners are inserted. These burners are 5-in. cast-iron pipes of a special form developed by the railroad company for this purpose, which have numerous small holes in the upper side opening into the furnace, with a 5-in. inlet on the lower side connecting through the ash-pit door to the gas valve. There are nine burners to each boiler, supplied through 1½-in. valves and connections from a 6-in. header covering the two boilers of each battery. This header is supplied by 6-in. connections from the gas distributing main on the basement ceiling directly under the boiler front. Provision has been made for adding Greene chain-grate stokers, if it be desired to use coal for fuel.

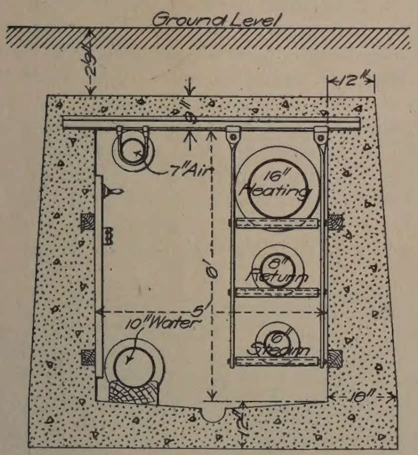


Boiler Room, Showing Gas-Fired Furnaces.

The boiler feed comes from the city works, supplemented by the condensation from the heating systems and the drips from the steam piping. All condensation and hot waste water, including the jacket water from the air compressors, is delivered to a Cochrane open feed-water heater, from which the boiler pumps draw, while make-up is supplied by an 8-in. connection from the 12-in. discharge line of the fire pumps. The boilers can be also fed directly from the mains. The heater is mounted on a steel platform 8 ft. above the firing floor at about the center of the room, and under the two feed pumps are below it. The heater is supplied with steam through an inductive connection from the 16-in. atmospheric relief riser from the engine room exhaust main, which discharges to the heater through an attached oil separator. The heater has a capacity of 2,000 h. p., and is fitted with chemical tanks for treating the water to remove a portion of the scale-forming impurities. The feed pumps are Fairbanks-Morse duplex pumps, each having 12x8x12-in. cylinders. They feed the boilers through a 5-in. main on the ceiling under the firing floor; this has 3-in. branches carried up between each battery and dividing into 2½-in. connections to each boiler. The boiler blow-off system consists of two 1¼-in. connections from the lower edge of the rear water leg of each boiler into a 4-in. blow-off main carried longitudinally through the boiler room in a trench at the rear of the setting. This main is carried out through the northerly wall of the building into one of the yard drains.

The steam piping systems are laid out with longitudinal headers for both high pressure and exhaust, the former in an elevated position on the boiler room side of the division wall and the latter in the basement on the opposite side. That for the high pressure system is a 12-in. header carried on cast-iron brackets 19½ ft. above the boiler room floor, with 10-in. branches to the boilers and eight 5-in. branches to the engine-room. The boiler connections are long-radius horizontal bends with a Davis automatic angle stop and check valve at the boiler nozzle and an angle stop valve at the header. The engine connections are made from the lower side of the header through Hoppes angle receiver-separators immediately below, from which the delivery lines lead down to the engines, compressors and pumps. The drainage of the header is effected directly by these separators, except at the ends, which are drained by two 1¼-in. connections. The condensation is removed from the separators and the header-end connections, and also from the throttle end of all steam connections, by a Holly loop system having a condensation receiving tank in the engine room basement and an elevated discharge chamber, together with the piping to return the condensation automatically to the boilers. The 16-in. exhaust header has eight 8-in. connections from the engines and pumps that pitch sharply downward toward it, and three delivery connections, one of full size which leads across to the feed-water heater and atmospheric relief riser in the boiler room and another connection of similar size at the north end of the power house through an oil separator into the piping tunnel for connection to the heating systems of the various shop buildings, with the exception of the store house, which is supplied by a similar 5-in. connection with oil separator at the southerly end of the power house. Condensation is drained from the receivers of the compound engines by Bundy steam traps which discharge to the sewer. A system of engine drains has also been provided so that the engine and pump cylinders and the receivers of the compound engines may be blown free in starting, the discharge being piped to the sewer. The oil separators in the connections to the low pressure heating mains are Bundy grease extractors from which condensation is drained to the sewer.

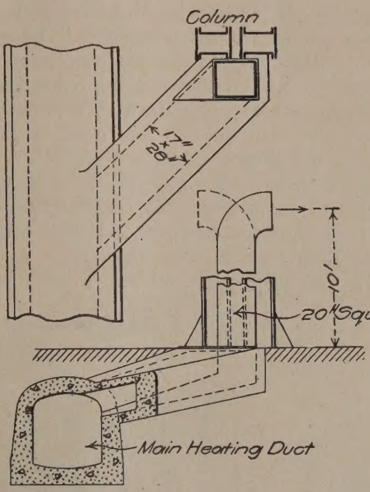
There are five tandem-compound four-valve engines direct-connected to 200-kw. generators of 2,000 cu. ft capacity per minute, another compressor of 1,000 cu. ft. capacity, and two large pumps. The engines are the Fitchburg heavy-duty side-crank tandem-compound type, with Tangye frames, and are designed to operate non-condensing with a considerable back pressure. They have governors of the centrifugal shaft type and double eccentrics for independent operation of the admission and exhaust valves. These units all have 14 and 22x21-in. cylinders and operating at 200 r.p.m., have a rating of 320 h. p. each. The air compressors are the Ingersoll-Rand compound two-stage type designed to deliver compressed air at a pressure of 100 lb. The two units deliver air through a 7-in. line to vertical steel storage and cooling tanks outside the building; these are 54 in. in diameter by 12 ft. high and from them the air distribution system of the shop plant is supplied through a 7-in. connection. The engines and compressors are all lubricated by a continuous gravity oiling system, consisting of an elevated storage tank supplying oil to all bearings and a collecting and filtering system in the basement from which the oil is pumped back to the tank. The two pumps are the Fairbanks-Morse underwriter type of 1,000 gal. capacity each, and draw from the reservoir and city water service as before stated.



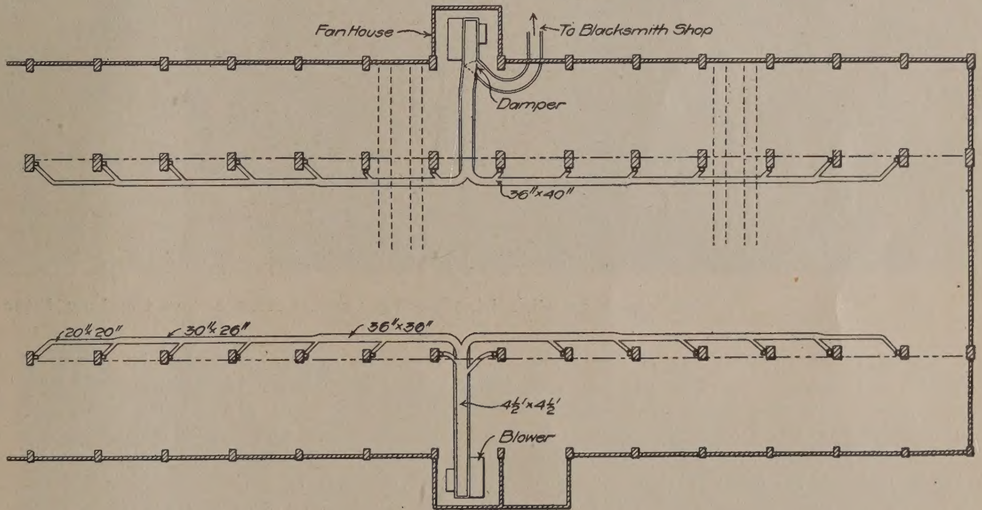
Section of Pipe Tunnel.

As before stated, the station supplies current for lighting both buildings and yards, the distribution system for which covers a considerable area, and for the power service in the buildings. For the former, an alternating current distribution was thought desirable on account of the distances of transmission which are over a mile in either direction. For the power service direct current was adopted to permit the use of variable speed motors for direct-connected machine tool drives. The generating equipment accordingly consists of three direct-current and two alternating-current units of 200 kw. capacity direct connected to the engines. The generators are all Westinghouse engine-type machines; those for the direct-current service are compound-wound multipolar machines delivering 230-volt current, and the alternating-current machines are of the revolving field type wound for two-phase current at 60 cycles and a potential of 2,300 volts. The alternators are arranged for excitation from either bus-bars of the 230-volt direct-current machines or from a 30-kw. motor-generator. No steam-driven excitor was necessary with this arrangement, as it is possible to start up the alternating current service by exciting the alternator field with current from any direct current generator, after which the motor generator set may be started for independent excitation to render the regulation independent of the voltage variations of the direct-current system.

The electrical distribution is controlled by a 18-panel switch-board, containing three generator panels, a total panel and three feeder panels at one end for the direct-current equipment, and two generator panels, an excitor panel, a total panel and four feeder panels at the opposite end for the alternating-current system. The switchboard equipment was supplied by the Westinghouse Electric & Mfg. Co., and contains oil switches for the control of the 2,300-volt alternating current and total recording watt meters for the measurement of the power consumed by either the direct or alternating system. There is also a small two-panel board for the control of the two-series alternating current arc lighting circuits, each operated by constant current transformers. The distribution system embraces nine circuits for direct-current, which are entirely local, and eight circuits for alternating current, four of which are for the new shop group and the others for transmission to other portions of the company's property. Of the direct-current system five feeders are carried to the locomotive shop for the crane motor and machine tool motor circuits, one each to the blacksmith shop and store house, and the remaining three to the old buildings for the operation of motors in the car shop. From the alternating current board, four feeder circuits supply local lighting in the main shop, blacksmith shop and store house, one the constant current transformers, and the remaining three the lighting at the old shops about 1,600 ft. distant. The freight department about 2,200 ft. distant, and the passenger depot about 4,000 ft. distant. The direct-current motor load, consisting of crane motors and machine tool motors in both old and new shops, averages about 400 kw., while the lighting load varies from 250 kw. to the uniform all-night load of about 150 kw.



Outlets of Heating Ducts.



Hot Blast Heating, Northerly Half of Main Building.

The new shops were laid out, and the buildings and their equipment, including the power plant, were designed by Mr. G. R. Henderson, who was consulting engineer to the Missouri, Kansas & Texas Railway. James Stewart & Co., New York, were general contractors for the shops. Mr. A. A. Allen is the vice-president and general manager of the system and Mr. W. O'Herin superintendent of machinery and equipment located at Parsons.

Sludge in Septic Tanks.

Septic tanks were first put in operation in the Lawrence Experiment Station of the Massachusetts Board of Health in 1898 and since that time tanks of this sort have been operated there. In the Board's last annual report there are some figures showing the disappearance of sludge which has been observed in the tanks; while such figures are applicable only to the local sewage they are of considerable interest because made with both concentrated sewage containing large amounts of suspended matter and with the regular station sewage. The two tanks receiving concentrated sewage were operated with storage periods of 18 hours to 15 days in one case and of 5 hours in another, and showed a disappearance of 82 and 75 per cent. of the sludge respectively. In the tanks receiving station sewage from 68 to 89 per cent. of the sludge disappeared. The detailed analytical and measurement results seem to show that more than 80 per cent. of the volatile organic matter deposited in the septic tanks in question is passed into solution or given off as gas. This is a deduction from analytical data, but it is of course difficult to obtain entirely representative samples. At times gas evolution causes sediment to rise and pass from the tanks, so that much matter passes off this way, which causes the figures showing sludge destruction to be greater than is actually the case. This fact has been pointed out in earlier reports of the Board. The analytical results show an apparent decomposition of much mineral matter, but this must be due mainly to the passage of this matter from the tanks without being detected. The time of storage within the limits of the experiments, ranging from 5 to 49 hours, except in the case of the 15-day experiments made with one tank in 1899, and the strength of the sewage seem to have little influence on the percentage of organic matter disappearing or on the number of pounds of dry sludge disappearing per million gallons of sewage. The average station sewage contains about 2,080 lb. of suspended matter per million gallons.

The Water Supply of Goldfield, Nevada.

The Goldfield, Nevada, mining district is in the center of one of the most desert regions in this country, where rainfall and moisture are almost entirely lacking and the aridity is pronounced and oppressive. In the face of the hardships and difficulties of living in a region of this kind, the remarkable richness of the mineral deposits of the district has attracted a large population, the town of Goldfield alone having about 22,000 inhabitants. The permanence of the resources of the district has been so well determined that an immense amount of money has already been expended in providing good transportation facilities, cheap electrical power and an adequate and suitable water supply to the isolated desert region in which the district is situated. The result of the provision of these facilities has been to change the camp of tents and temporary shacks into a city with pavements, electric lights, water works, sewers and other modern improvements. The construction of these improvements has been carried on at very unusual expense owing to the isolation of the district and the cost of transportation and labor.

When the richness of the mineral deposits in Goldfield and vicinity was discovered in 1903 the town was 100 miles from the nearest railroad, and for over a year after the wealth of the region was exploited no railroads were put under construction to reach the district. Since then, however, three standard-gauge lines have been built into Goldfield, providing good transportation facilities. The first of these was the Tonapah & Goldfield R. R., an extension of a branch of the Southern Pacific R. R., 100 miles in length, the branch connecting with the main line of the latter road at Reno, Nev. The second was a branch of the San Pedro, Los Angeles & Salt Lake R. R., 220 miles in length. A third railroad, the Tonopah & Tidewater, is just being completed from Tonopah through Goldfield to a connection with the main line of the Atchison, Topeka & Santa Fe R. R., with a total length of 326 miles. Practically all of this railroad construction was carried on in desert country, where water for all purposes frequently had to be hauled 30 to 50 miles, and, in instances through districts where no work could be done in the summer on account of the terrific heat. Some of the grading required also involved a large amount of work, so the cost of these lines has been excessive.

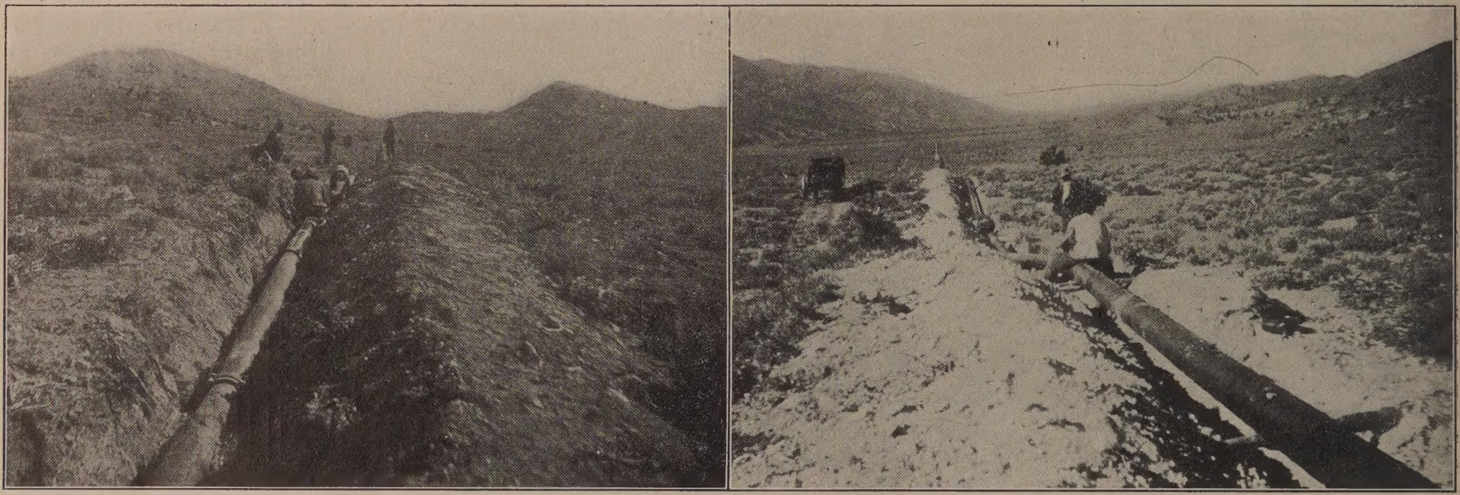
Electrical power for the Goldfield district, and for several other mining districts in the vicinity, is furnished from the extensive hydro-electric developments of the Nevada-California Power Co. on Bishop Creek in California, 113 miles from Goldfield. This creek is a tributary of the Owens River, from which the new water supply for Los Angeles, Cal., is to be obtained. It has its source in a mountain range which is covered with perennial snow, and its flow is remarkably uniform throughout the year. The power company has two hydro-electric stations, with a combined capacity of 7,500 h.-p., in operation, and is constructing two more stations, which will give an ultimate total capacity of 14,000 h.-p. Much additional power can also be developed as the company controls 3,200 ft. of fall on Bishop Creek, and large storage reservoirs can readily be built on the headwaters of the stream at a reasonable cost. The power generated is transmitted to Goldfield at 60,000 volts over a pole line 113 miles long, and branches from this line are extended to other points. Much of the transmission line was built through the rough mountain country and thence across the desert at a very great expenses. The whole power development project has been more than justified by the demands to be supplied, however, and will keep pace with these demands with difficulty.

Although ample railroad and power facilities were thus constructed at a great outlay, the provision of an adequate supply of satisfactory water remained to be accomplished. Such a supply has now been developed in the mountains, 30 miles from Goldfield, and the pipe line which delivers it to the city was recently placed in operation. Prior to the completion of this pipe line water was obtained from a mine and from various small wells and springs. All of this water was highly impregnated with alkali salts and practically none of it was suitable for domestic consumption. The salts contained in it were also of such nature that the water was highly unsatisfactory for use in boilers, or in the concentrating mills required to work a large portion of the ore which is mined in the district. Furthermore, the supply was entirely inadequate, so no fire protection could be provided and water commanded an apparently unreasonable price.

The chief part of the original supply was obtained from a mining company, which pumped water about 10 miles against a head of 800 ft. from a series of alkali springs, for use in a concentrating mill. These springs produce about 36,000 gal. per day, and the mining company sold the surplus over the requirements of its mill to a local water company at a flat rate of half a cent a gallon. The other springs and wells from which water was obtained were at varying distances from the town, but were all of small capacity. Two small and separate systems of distribution mains had been laid in the central part of the town, and water was retailed at three-quarters of a cent a gallon to consumers connected with these mains. Beyond the limits of the distribution mains water was delivered in barrels on wagons at prices of 1 to 3 cents a gallon, depending on the distance it had to be hauled. Under these conditions it cost $750 a month for enough water to run an 80-h.p. boiler; it also cost 25 cents to water a team of horses, and fire insurance could not be obtained owing to the lack of fire protection. In fact, a disastrous fire occurred, which could not be checked because no water was available. The inauguration of the new water supply has changed all of these conditions, as an ample amount of good spring water from the mountains is now available under a pressure that provides fully for fire protection.

The mountains in which the supply has been developed are 25 to 30 miles from Goldfield, along the western edge of the desert. The development has been made on, or in the vicinity of Mount Magruder, which is covered with snow until late in the summer. The surface of the upper part of this mountain is largely loose, disintegrated granite, with rocks of considerable size, which grade into gravel down on the mountain sides, and finally into the soil of the desert. Practically none of the melting snow ever runs off in streams and very little of it shows on the surface along the sides of the mountain, most of the water flowing away under ground and being dissipated through the dry soil of the desert below. In a few places along the side of the mountain, where the bed rock nearly outcrops at the beginning of the overlying gravel, several small springs appeared, and other conditions indicated the presence of an underground flow. At several of these points horizontal tunnels have been driven back into the side of the hill to intercept the sub-surface flow and to increase the output of the springs.

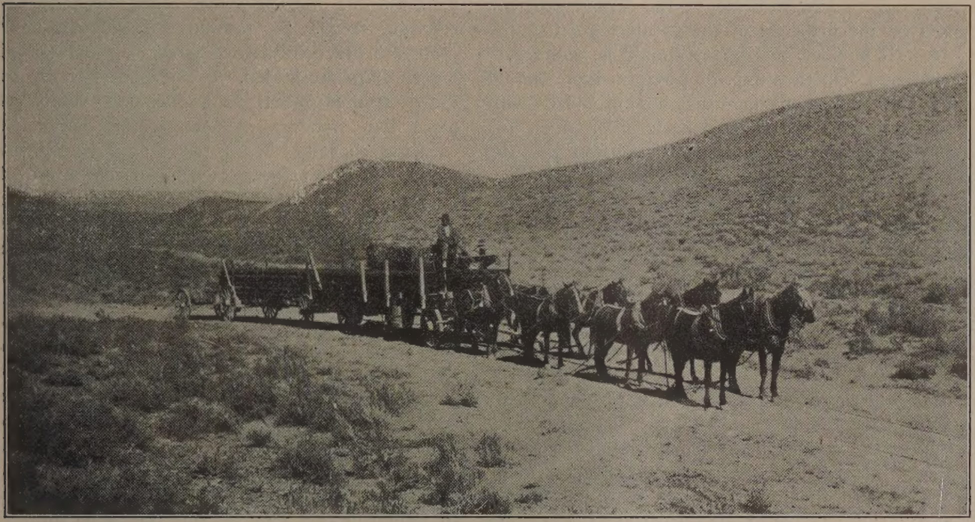
One of the principal sources of supply that has been developed in this manner is from Cartee Spring, across a canyon from Mount Magruder, at the base of a mountain of similar formation. This spring, which flowed upward of 80,000 gal. a day before it was developed, and had been used for 30 years in irrigating a small ranch, now delivers at least 100,000 gal. a day. The Gusher Spring, another one of considerable flow, is on the side of Mount Magruder, about 5 miles up the valley from the Cartee Spring. Three miles around the mountain from the Gusher Spring are the three State Line Springs, the water from which was used for years in placer mining. Another series of three springs has been developed on the side of Mount Magruder, between the Cartee and the Gusher springs, and



Two Views on Pipe Line during Construction across the Low Intervening Country.

three more exist adjacent to these. The springs which have been developed are perennial and have a normal daily flow of over 1,000,000 gal. Other large springs remain to be utilized, chief among these being the Hyde Spring, which will deliver 200,000 gal. of water in 24 hr., but is lower than the pipe line, so its flow will have to be pumped when required.

The tunnels which have been built into the side of the mountain to develop the underground flow involve no special features. They were usually driven so the bottom of the tunnel was at, or very close to bed rock, and were continued back into the side of the mountain until they intercepted the crevasses or channel through which the underground flow comes down the mountain. The total flow is thus conserved and the original capacity of the springs increased from 60 to 100 per cent. The tunnels were made about 6 ft. high, 3 ft. wide at the top and 4 ft. wide at the bottom, and have lengths varying from 20 to 160 ft. They were heavily timbered throughout to hold the loose material through which most of them had to be driven.



Hauling Pipe from the Railroad Station.

The various springs that have been thus developed are connected by a line of spirally-riveted steel pipe which is merely a continuation of the pipe line leading to Goldfield. This line starts at the State Line Springs and extends as a 6-in. pipe for three miles to the Gusher Spring, the fall in this distance being 32 ft. From the Gusher Spring to the Cartee Spring, in a distance of 5 miles, the fall is 1,200 ft., so a 5-in. pipe is fully sufficient to carry the flow. The series of three springs which have been developed on the side of Mount Magruder are connectetd to the 5-in. line by a 5-in. pipe.

Three miles toward Goldfield from the Cartee Spring is a summit, called Lida Summit, which is only 27 ft. below that spring, so in order to secure the desired capacity a 9-in. pipe was used for the main line in this distance. From the Lida Summit the country drops away rapidly, the line crossing a valley about 20 miles wide before reaching a second summit, called Malapi Summit, at the edge of Goldfield. The drop in this 20 miles is about 900 ft.; the Malapi Summit is 500 ft. lower than the Lida Summit and 400 ft. above the town. It was originally intended to operate the pipe line by gravity, but a pressure of over 390 lb. per square inch would thus have been brought on the section of the line between the two summits. The decision was made, therefore, to place a pumping station part way up on the rise to the Malapi Summit and operate the section of the line between the Lida Summit and this station by gravity, and thence pump the water against a head of about 150 lb., over the Malapi Summit. This arrangement permitted ordinary 7-in. spirally-riveted pipe to be used between the Lida Summit and the pumping station.

The flow line is all placed at least 18 in. below the surface, which is sufficient depth to protect it from frost in the region traversed. Air valves are provided at all summits and blow-off valves at low points, at intervals of about two miles. Owing to the nature of the country and the absence of rainfall, no waterway crossings had to be built, nor protection against washing provided at any point.

The pumping station contains a single 400,000-gal. Goulds triplex pump, belt-driven by a 50-h.-p. electric motor. A second unit of the same type will be installed when required. Electrical current is obtained from the Nevada-California Power Co. The pump delivers into an 8-in. pipe line 6,000 ft. long, which leads over the Malapi Summit to storage tanks on the side of the latter. Several temporary tanks, with a combined capacity of 400,000 gal., are at present installed, but two new tanks, with a capacity of 200,000 gal. each, will be placed to provide for the variations in domestic consumption. One of the present tanks, with a capacity of 200,000 gal., will be retained for storage for fire purposes. These storage tanks will render available in the town a pressure of 50 to 60 lb. for domestic consumption and of 120 lb. for fire protection.

Mountains in Which the Supply was Developed; Desert in Foreground.

The distribution mains of the two original water supply companies operating in Goldfield were purchased by the company which made the development of the new supply. One of these systems was made up of spirally-riveted pipe and the other of standard well-casing and machine-banded wooden pipe. As parts of these systems were small pipe, and nothing smaller than 6-in. pipe will be used in the main part of the town for the new system, much of the original work is being replaced. In all new work lap-welded wrought-iron pipe, with Converse joints, is being used. All connections to the distribution mains are metered, water for domestic consumption being sold at ¾ cents a gallon and for commercial purposes at $2.50 to $4.00 per 1,000 gal.

The chief difficulty encountered in the construction was in building the pipe line across the 20 miles of desert between the two summits. All of the pipe for the entire line had to be hauled from the railroads at Goldfield. Water for all purposes frequently had to be hauled 15 miles. The trench for the line was opened up with eight and ten-horse teams on plows, but a hard, cemented conglomerate encountered just under the surface required a large amount of light blasting and greatly increased the cost.

An analysis made of the water from the new supply showed only 21.04 gr. per gallon of solids, with but 0.44 gr. of suspended matter and a trace of organic matter, while nitrates and nitrites were absent. The water, therefore, contains nothing to make it objectionable for domestic use. The percentage of scale-producing salts, the sulphates, which are the only corrosive salts present, and those salts which produce foaming, are all low, so with reasonable care the water can be used for boilers with no deleterious results. Carbonates predominate in the water, but are remarkably low, as compared with other waters in the country surrounding Goldfield. In fact, this analysis showed the water to compare favorably with most domestic supplies, which is a remarkable circumstance in this desert country in which the supply has been developed.

The scheme of securing water for Goldfield from the mountains was devised by Mr. Loren B. Curtis, of Denver, Colo., who, assisted by Mr. Charles G. Patrick, conducted the investigations of the source of the supply, prepared the plans for the work and supervised the construction. The water supply system and distribution mains are owned and operated by the Goldfield Consolidated Water Co., which is controlled by Denver and Goldfield interests.

TWO SCHOLARSHIPS in McGill University, Montreal, will be given by the Canadian Pacific Ry. to those employees or sons of employees who stand highest in entrance examinations next year. There are three students now holding such scholarships.

Methods of Increasing the Capacity of the New York Subway.

When the New York Subway railway was put in service, a good many people thought that the rapid transit problem in Manhattan was solved for at least a decade. Before the first operating year had passed, this belief had vanished. The difficulties of travel on the road during the rush hours proved even greater than on the elevated lines and came somewhat near the disgraceful scenes in evidence about six o'clock any week day afternoon at the Manhattan terminal of the Brooklyn Bridge. Naturally enough the overcrowding was attributed by the public to the lack of enough trains, but the correctness of this opinion seemed questionable after some study, and the fact that the subway was about taxed to its utmost gradually became apparent to those who observed the conditions critically. Pending the construction of more subways, it is necessary to utilize this one to the utmost, and so the Public Service Commission retained Mr. B. J. Arnold to study the conditions and suggest methods of improving the service now rendered by the Interborough Rapid Transit Commission. The full report on this subject is not yet written, but a preliminary report was made last week, from which the following extracts have been made:

It is but fair to say that, taking into consideration the circumstances under which the subway was built and is now being operated, it is one of the best constructed and best operated railways in existence. On the other hand, the service demanded of it is far in excess of that of any other road, and as a consequence conditions are now such that although the time card calls for a headway of 2 min. between trains south of 96th St. during rush hours, in actual operation the trains fall behind this schedule from 12 to 30 sec. under normal conditions during these hours. This results in only about 25 express trains per hour leaving Grand Central Station instead of 30 trains, as called for by the time card.

After studying the causes of delay, Mr. Arnold is convinced that several of them can be promptly removed and the 2-min. headway, as given by the time card, maintained under normal conditions during rush hours. Many of these delays are due entirely to the excessive time taken for loading and unloading trains at the platforms, and are caused largely by the policy of holding the trains at the stations until all the cars are jammed full of passengers, in an attempt to clear the station platforms. This policy should be changed to one of starting the trains within a fixed time after they have stopped in order that the maximum number of cars may be made to pass through the stations after allowing reasonable time for loading. This time of loading and unloading the express trains should be limited to 45 sec., instead of an average of 65 sec. taken at present at Grand Central Station. This can be accomplished provided the proper degree of efficiency is maintained by the platform men and train guards, by putting into effect the following method of operation:

First. In view of the fact that northbound evening express trains leaving Grand Central Station carry approximately 25 per cent. more passengers than are brought into this station from 14th St., a system of loading should be adopted, which will regulate the loading at Brooklyn Bridge and 14th St. in such a way that there will be capacity left in the cars for the increase of load at Grand Central Station, and thus avoid the present excessive crowding.

At present time the cars come into Grand Central Station fully loaded, and the delay at the station platforms is caused largely by passengers getting off slowly from crowded cars and the difficulty of loading so many additional passengers into cars already full. The delay caused by this congested condition of the cars at Grand Central Station soon backs the trains up in the subway as far as 14th St., and as the trains are held at 14th St., they are naturally loaded more fully, and thus the congestion is increased automatically, which can only be remedied by a combination of systematic loading and prompt movement of the trains.

In other words if part of the passengers who are ready to enter the trains at 14th St. are cut off, all trains can be moved on time, and therefore, more trains operated than at present. Thus additional speed and comfort can be obtained for all of the patrons of the subway by a small amount of inconvenience to a few patrons who are slightly delayed in taking the cars at 14th St., and on the principle of the greatest good to the greatest number, this policy should be adopted.

Second. On each express platform there should be stationed a train dispatcher provided with two stop watches, one for the local the other for the express service, with instructions to give the signal for closing the doors not later than 40 sec. after the train has come to a stop, thus allowing 5 sec. to close the doors and start the train within a 45 sec. period. Subsequently indicators visible to the passengers can be installed which will show them the time in seconds remaining before the closing of the doors.

Third. The guards upon the cars should be instructed to open the doors as soon as the train has stopped. There is now at times a noticeable delay in geting these doors opened. The train guard should also be instructed to listen attentively for the closing signal, and at once make every effort to close the doors with the assistance of the platform attendants, and when the doors are once closed they should be kept closed instead of being opened occasionally to let off a delinquent passenger.

Fourth. Train guards should be instructed to keep themselves more alert and to transmit promptly the starting signal. If it is found that the guards cannot be trained to attend to this matter of signaling promptly, it may be necessary to require an electrical system of signaling whereby the motorman will get the signal on the instant the last door is closed.

Fifth. The station attendants should be given positive instructions to act promptly when the signal is given for closing the doors. This can be done by positively regulating the stream of passengers entering the car so that the last passenger in will not obstruct the closing of the door.

In order to secure better service for the patrons of the subway the Interborough officials have pointed out that suitable police regulation on the station platforms should be provided in order to control such individuals as may interfere with the prompt closing of the doors. [The police department has now provided such special officers].

By making other improvements it will be possible to reduce the headway still further, for the present signal system is arranged so that by slightly changing it at the stations trains can be easily operated on a 90-sec. headway, if such a headway were not prohibited by excessive station stops. Mr. Arnold suggests that the Interborough officials be requested to prepare a train schedule on the basis of a 105-sec. headway during rush hours, which is a reduction from the present schedule of 15 sec. This saving in the headway can be secured at once by changing the block signaling system at the express stations. At the present time the station block is not cleared until the leaving train has nearly left the platform. With an eight-car train on the express tracks it requires from 22 to 25 sec. after a train starts to get the signal which allows the following train to proceed. It then requires a certain length of time for the following train to pull into the platform and come to a stop. For example, at Grand Central Station this time amounts to 50 sec. for a north-bound train. If the signal to the following train could be given at or about the time the leaving train starts rather than waiting until the train has cleared the platform, the 15-sec. saving could be effected at express station stops.

Mr. Arnold is studying the necessity of changing the design of the present cars so as to provide one or more openings in the sides, but he cannot reach a fair decision until the effect of the improvements suggested above, or their equivalent, has been shown.

There will always be the problems as to where to draw the line between seating capacity and standing room. At present during rush hours there are practically twice as many people standing as there are seated. If more seats were provided in the present cars, one seat would displace two standing passengers, and either the carrying capacity of the car would be reduced or the standing passengers would be more crowded than at present, which seems practically impossible. As it is impracticable to use wider cars, owing to the lack of clearance in the present subway, the only method of providing more seats is to provide more of the present type and size cars, but with more cross seats, which method would tend to greatly increase the time required for loading and unloading them. As soon, however, as the service of the subway becomes improved either by providing additional seating capacity or by more rapid service, instead of this service creating additional comforts to those who are now riding more people will be attracted by this superior service, and the applicants for seats will outnumber the available seats in practically the same ratio as at present. It is, therefore, evident that a decision must be made, relative to the general nature of the service to be supplied, before the proper type of car can be determined. The desirability of providing a certain number of passengers with a maximum number of seats, and thereby limiting the capacity of the subway to practically the number of seats that can be made to pass any given point within a given time must be compared with the desirability of providing transportation to the greatest number of passengers possible, even though a large majority are compelled to ride for a short time without being provided with seats.

It has been contended not only by those who have suggested certain methods for improving the subway service, but also by the advocates of better service in most of our large cities, that each passenger should be provided with a seat, or at any rate, that whatever improvement is attempted should tend to increase the seating capacity of all cars operated over the seating capacity of those now in use. There is no question as to the righteousness of this contention, but the futility of attempting to furnish such service to all patrons of the road may be judged any evening by the most casual observation of the crowded conditions of the present subway cars. If the policy is adopted of providing seats to the majority of those who ride during rush hours, it will result in a material decrease in the total number of passengers which it is now possible to transport in the subway, and would therefore result in turning away many passengers who now make use of its service.

If the principle of a slight reduction in the seating capacity of the present cars can be adopted, increased carrying capacity can be obtained by eliminating all or a part of the present cross seats. Their elimination makes it practicable to introduce center side doors into the present cars, should this change be found necessary later. In case the traffic cannot be properly handled nor the desired 45-sec. limit for station stops be maintained with the present end door cars, the use of those center doors in connection with the absence of cross seats will make it practicable to load and unload so rapidly that this limit can be maintained.

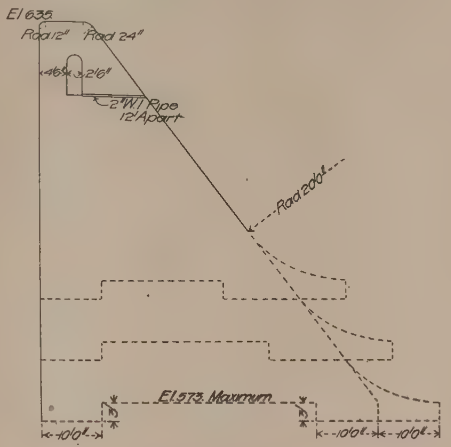
No one having the best interests of the public at heart will deny that if it were possible to provide each passenger with a seat throughout his entire journey that this should be done, but as it is practically impossible during rush hour periods in most transportation systems now existing in the principal cities of this country, the question of just how far this principle can be departed from and still serve the best interests of the public by providing as many seats in the cars as practicable requires most careful consideration.

The hardship imposed upon those who are compelled to stand in the subway cars during the rush hour period is not as great as it at first appears to be, for the reason that, owing to the transfer system between the express and local service, so well worked out in this railway, few passengers are compelled to stand for any great length of time. This is brought about through the fact that the passengers in each car are changed so often, due to transfers at express stations, that many of those who stand at first soon get seats, compelling the newcomers to stand, who for like reason and in turn soon find seats.

In further support of the policy favoring increased standing room in the cars it is but proper to point out that the reason for diminishing the number of seats is for the purpose of providing greater aisle space so that a system of circulation of passengers from the entrances toward the exits of the cars may be more easily maintained, resulting in greater comfort not only to those standing but also to those seated, and at the same time avoiding the conflict of streams of passengers with its resulting discomfort, now so evident at the express stations during the rush hours. As an additional result of maintaining a definite circulation of passengers, greater expedition will be possible in loading and unloading, station waits will be reduced, and the average speed of travel materially increased, so that the discomfort of standing is further lessened by being shortened.

The question then tersely stated is as follows:

Having 60,000 people to carry per hour, shall we, by following one policy, provide seats for 40,000 people with standing room for possible 10,000 more, and turn away 10,000 to other and slower means of transportation, or by adopting, at least until future subways can be built, the other policy whereby increased standing capacity is obtained, provide seats for 20,000 and carry the other 40,000 standing for short intervals of time, and thus furnish transportation for the entire 60,000. Inasmuch as an answer to this question involves a decision based upon public policy rather than upon engineering feasibility, Mr. Arnold feels that the Commission should first pass upon it and instruct him accordingly.



Section of Dam.

Cableway Tower on East Side of River.

View of Lock Basin, Looking Upstream.

A Car Ferry service across Lake Ontario has been placed in operation between the Genesee River, above Rochester, N. Y., and Coburg, Ont., a distance of 60 miles, by the Grand Trunk and the Buffalo, Rochester & Pittsburg railways. The boat, which is expected to make two round trips in 24 hours, is said to be the largest on Lake Ontario, being 316 ft. long, 57 ft. 4 in. beam and drawing 17 ft. It has a capacity of 26 cars and is expected to develop a considerable coal carrying trade. Though intended primarily for freight, passenger accommodations have been provided on the upper deck.

The Chattanooga & Tennessee River Power Company's Plant.

By Howard Egleston, C. E.

During the past ten years the growth of Chattanooga, Tenn., has been very remarkable, and there is every prospect that her future development will be even greater than her past. Blest with cheap coal from nearby fields, her cost of power has been very low; add to this her location, central to immense developments of iron, great forests of hard wood, and many other raw materials, her wonderfully good transportation facilities, and we have the reasons for her being one of the largest manufacturing cities in the South. But in addition to these advantages, nature has furnished another, hitherto not utilized—the Tennessee River as a source of power.

For nearly three-quarters of a century U. S. Army Engineers in charge of the improvement of our inland waterways have studied the improvement of navigation of this river where it breaks through the mountains near Chattanooga. Finally, in 1900, it was practically determined that a dam and lock should be built at Scott Point, 17 miles below Chattanooga, if an appropriation could be obtained from Congress, but some of Chattanooga's wide-awake citizens had been impressed by the success attending the development of water power in other Southern cities, and Messrs. C. E. James and J. C. Guild took the matter up with great energy. By demonstrating the enormous benefit, commercially, that would accrue to Chattanooga, if the power of the river could be converted into electrical energy and brought to that city, they secured the co-operation of Representative John A. Moon, of their district, in obtaining the necessary legislation, and finally in 1904 an act was passed authorizing the Secretary of War to grant permission to the City of Chattanooga to build and construct a lock and dam across the Tennessee River at Scott Point. The act also provided that if the city did not accept this privilege within four months from the date of passage of the act, then the Secretary of War should offer the franchise to Messrs. James and Guild for a period of eight months, and failing to contract with them, to contract with any private corporation, firm or business, for the construction of the lock and dam. The citizens of Chattanooga did not accept the offer, but Messrs. James and Guild organized the Chattanooga & Tennessee River Power Co., with Mr. A. N. Brady in charge of the financial end, Mr. John Bogart becoming consulting engineer for the company.

Scott Point has been selected as being the place where the greatest improvement to the river could be made at the least cost, but when the plan was changed from simple river improvement to the development of power, it was decided that greater power could be secured, together with an equal or greater improvement to navigation, by constructing the lock and dam further down the river, at Hale's Bar, 33 miles below Chattanooga. Another act of Congress was therefore obtained in January, 1905, authorizing the location of the dam at such other place below Scott Point as the Secretary of War might approve.

The designs for lock and dam were prepared under Major H. C. Newcomer, Corps of Engineers, U. S. A., by Mr. John M. G. Watt, principal assistant engineer. The power house and all appurtenances for developing the water power were designed by Mr. Bogart.

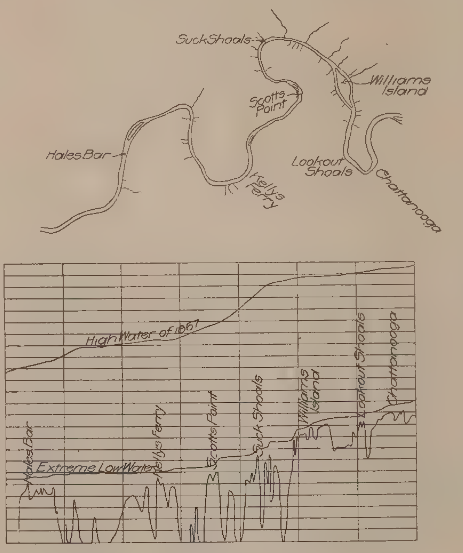
The lock and dam will be built of Cyclopean concrete, making all walls solid except for a passage through the dam and the necessary culverts for filling and emptying the lock. The total length of lock, dam and embankment between the rock bluff on the west side of the river and the hill where the embankment terminates is 2,300 ft., the dam being 1,200 ft. long, power house 300 ft. and embankment 700 ft. The top of the lock walls will be 52 ft. above present low water, or 58 ft. from foundation to top and 17 ft. above crest of dam. This will allow operating the lock in times of flood of 35 ft., though at that time the river would be 14 ft. above the crest of the dam.

The walls of the lock on the land side will be 30 ft. at bottom and 5 ft. at top, except for the buttresses supporting the gates, where the top will be increased to 25 ft. and the bottom to 33 ft. The river side walls will be 32 ft. wide on bottom and 8 ft. wide on top, widened at the buttress supporting the gate at the upper end to 25 ft. on top and 35 ft. at bottom; and at the lower end to 25 ft. on top and 46 ft. on bottom. In each wall will be built culverts 11 ft. high by 6 ft. wide, running the entire length of lock chamber, and each having ten openings 3 ft. below low water, by means of which the lock chamber will be filled. It will be emptied by two culverts of similar size, having their openings into the lower bay. Stoney sluice gates, operated by electric power, will be used to open and close these culverts.

Core Wall of Embankment between Bluff and Power Plant.

The gates of the lock will be of the mitering type, horizontally framed, of mild steel, opened and closed by electric motors operating through rack bars. Provision will be made for operating by hand power should electric current fail. In extreme low water, with flash boards on the dam, the difference in height between the upper and lower pools will be over 40 ft. The gates to hold back this great mass of water must be of extraordinary strength; each leaf of the upper gate will be 34 ft. wide by 26 ft. high, weighing about 50 tons, while those of the lower gate will be each 34 ft. wide by 59 ft. high and weigh 130 tons.

Should the gates become damaged at any time the lock can be closed by using five steel trestles at each end. These will be fitted into journals placed in the concrete during the construction of the lock. To these trestles will be attached steel beams, against which will rest vertical needles of steel or wood.



Course and Profile of River.

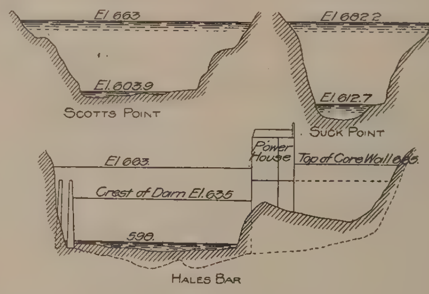
Through the whole length of the dam will run a passage 2½ ft. wide by 6½ ft. high, its floor being 12 ft. below crest of dam. From the bottom of this passage will run every 12 ft. a 2-in. wrought iron pipe, extending to the downstream face of the dam, to supply air under the water passing over the dam. The passage will furnish a mode of crossing the river from the power house to the lock and carry the wires for furnishing electric power and light.

The power house will have seven bays, each containing two units. Each unit will consist of a generator and three turbines. This use of three turbines is made necessary by the great variation in the volume of water in the river. In ordinary heights of water only two of the turbines will be used; the third wheel is to be used when a large quantity of water is flowing, but with a reduced head. Under ordinary conditions of the river the head at the dam will be 36.5 ft.; this may be increased to 39.5 ft. by the use of flashboards.

The generators to be used will be each 4,000 kw. At present it is the intention of the company to install at first only eleven of the fourteen ultimately to be used.

The transmission line is planned to consist of two three-phase lines, both mounted on the same line of poles and carried in as straight a line as possible from the transformer room at the dam to the receiving station in the city, a distance of about ten miles.

The contract for the lock, dam and power house was made with W. J. Oliver in 1905 on a quantity basis, the work to be completed in two years, or in the summer of this year. Apparently a great miscalculation was made, for at this writing, the middle of October, nothing has been done on the dam or power house, and the only evidences of progress are shown in the partly completed core wall for the shore embankment and the coffer dam for the lock, which has been raised to only 10 ft. above low mark. I do not believe it possible to finish this work under two years, and it is quite possible that a destructive flood may considerably increase this time. To complete the work within two years the working force and plant employed will have to be greatly increased. The General Electric Co. will furnish the electric equipment.



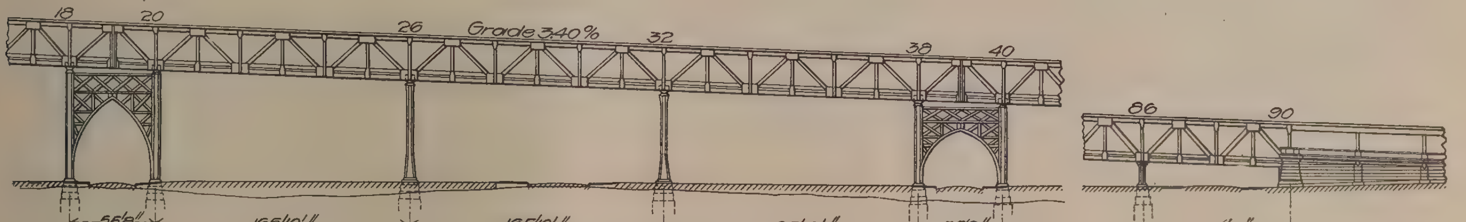
Sections of River.

It is the intention of the power company to furnish electric power at not more than $20 per horse-power per year, and they have already contracted for 50,000 h.-p., or practically the entire horse-power now used in the city. This rate will be about one-half of the present cost of power and is sure to cause many industries to locate in this favored city.

The Kaiser Wilhelm Canal connecting the Baltic and the North Seas has become too small for the demands of the traffic, and its enlargement and improvement have been proposed. The present profile is 29½ ft. deep at mean water level, 72 ft. wide at the bottom and 220 ft. at the surface. It is proposed to deepen it to 36 ft. and increase the width at the bottom to 144½ ft. and at water level to 334 ft. It is proposed to increase the length of the locks to 1,083 ft. and the width to 147½ ft., with a depth of 45 ft. at mean water level, which is equivalent to 39 ft. at low water. At two points it will be necessary to change the alignment, because the curves are too sharp for large, modern vessels. The present radius is 3,935 ft. and the proposed radius 5,866 ft. Beyond these two instances no change is proposed in the line of the canal. The passing stations are to be increased in number and will be, with the former ones, about 6 miles apart. The cross section of these stations is to be 440 ft. at the bottom and 624 ft. at the water surface. Turning stations will be created at four points by enlarging four of the passing stations, so as to have a length of 3,919 ft. a bottom width of 538 ft. and a surface width of 722 ft.

The Queens Approach to the Blackwell's Island Bridge, New York.

The approach to the east or Long Island end of the main spans of the bridge across the East River and Blackwell's Island has provision for two elevated railroad tracks, four other railroad tracks, a carriage way and two sidewalks. It consists chiefly of a steel viaduct with spans of from about 56 to 166 ft. It it 86 ft. wide over all and about 2,663 ft. long from the center of the anchorage pier to the entrance, including about 333 ft. of solid fill between masonry retaining walls at the entrance. The carriage-way and the four surface tracks, rise at a uniform grade of 2.4 per 100 from the surface of the ground at the entrance to a height of about 100 ft. above the ground or 112 ft. above mean low water at the anchor pier. It lies wholly in the borough of Queens and crosses eight streets and boulevards in the suburbs of Ravenswood, Long Island City. Like the main spans of the bridge and the Manhattan approach, described on Nov. 23, it has two decks, the upper one about 63 ft. wide over all, carrying in the center the two elevated railroad tracks and on each side a foot-walk about 14 ft. wide in the clear. The lower deck, about 21 ft. 9 in. below the base of rail of the elevated track has a clearance of about 15 ft. 9 in. under the transverse girders of the upper deck. It is 86 ft. wide over all, corresponding to that of the main spans and differing from the Manhattan approach, which is much wider and is in accordance with the totally different types of construction, being more suitable for the cantilever construction adopted here for the support of the outside tracks which in the Manhattan approach are carried directly by vertical columns under the extremities of the transverse girders.

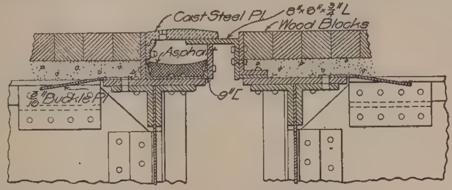


Part Elevation of Queens Viaduct of the Blackwell's Island Bridge.

This steel superstructure consists essentially of groups of five spans each, supported on towers 55 ft. 8 in. long and on two transverse bents intermediate between each pair of towers. The lengths of the main spans are proportioned in accordance with their height above the ground, varying from 97 ft. at the lower end to 131 ft. 4 in., 145 ft. 6 in., and 165 ft. 10½ in. at the bridge ends. The minimum clearance of the completed superstructure above the surface of the ground is about 15 ft., and the towers and vertical columns are so located that they clear the intersecting streets, four of which pass through the towers.

Unlike the Manhattan approach this approach has no subway station or depressed tracks, all of the surface tracks leaving the bridge at grade at the Crescent St. entrance, where the only structure of an auxiliary character is the stairway leading to the end of the elevated railroad tracks which may later on be joined to a connecting line in Ravenswood. The embankment approach has a clear width of 86 ft. uniform with that of the lower deck of the steel viaduct and has retaining walls 333 ft. long and 20 ft. in maximum height above the surface of the ground. They are of concrete offset in the rear and battered in front where they are faced with granite down to a few inches below the surface of the ground. They are 3½ ft. wide under the coping and are 10 ft. wide at the base for a height of 20 ft. The filled embankment between them is covered with 6 in. of concrete on which the wood pavements, railroad tracks, and electric conduits are laid and in which there are four lines of electric ducts. The columns for the elevated railroads are carried down 5½ ft. below the surface of the roadway where they are seated on separate offset concrete piers of a maximum height of 16¼ ft. and footings on dense sand. A cast-iron guard encloses the column to a height of about 18 in. above the roadway, and below its top the column is entirely enclosed in a solid mass of concrete.

The elevated railroad structure is substantially the same throughout the length of the approach whether it is supported by the steel viaduct or on the filled embankment. The principal difference is in the feet of the columns, which in one case are seated as already described on masonry piers, and in the other case are the regular vertical posts at the panel posts of the main trusses which carry the lower deck. Accordingly, in the viaduct spans the transverse girders of the elevated structure, about 22 ft. apart, directly support the four lines of track stringers and the four lines of sidewalk stringers, all of which are plate girders, respectively 48 in. and 42 in. deep.



Expansion Joint in Roadway.

The sidewalks are carried by 7-in. transverse I-beams supported on each side of the bridge by two lines of stringers and by the top cords of the truss. At the end of the steel viaduct there are eight 44-ft. elevated railroad spans supported by the vertical columns. Each of them has eight lines of 48-in. longitudinal plate-girders web-connected to the transverse girders 6 ft. deep that are supported by the vertical columns 60 ft. apart transversely, to which they are connected by vertical web angles and by deep solid-plate kneebrace brackets. There are also two lines of fascia girders 3½ ft. deep riveted directly to the columns and each carrying, together with two adjacent lines of longitudinal girders the transverse sidewalk floor beams on cast-iron filler blocks. The floor panels are X-braced with single 6-in. horizontal lateral angels web-connected to the transverse girders about 2 ft. above their bottom flanges. The sidewalks are made with reinforced concrete floor slabs and have hand rails with cast-iron bolts, cast pipe rails and riveted lattice work webs.

The transverse girders have 7-16-in. web-plates reinforced to 1 3-16-in. thick at the ends and each flange is made with a pair of 8x8x13-16-in. angles and three 18-in. cover plates of different thicknesses and lengths. The columns are vertical and the transverse girders are riveted to them at a slight angle to correspond with the angle of the grade.

The longitudinal girders have their fixed ends field riveted to the webs of the transverse girders and their expansion ends are supported in pockets made with pairs of vertical angles riveted to the webs of the transverse girders and connected at the bottom by a reinforced horizontal shelf angle. The bottom flange of the longitudinal girder slides freely on the shelf angle and the top flange is guided between the vertical pockets by short longitudinal angles riveted to the under side of its top flange and forming transverse bearings.

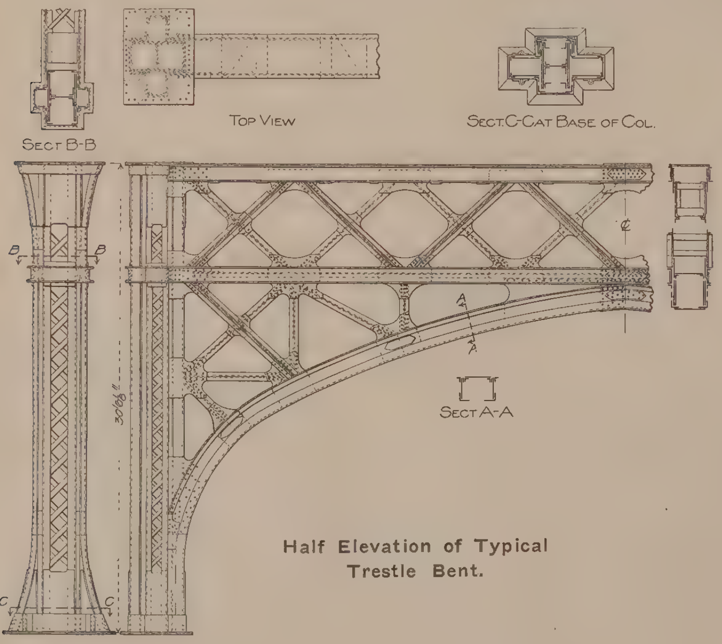
The four viaduct towers vary in height from about 20 to 80 ft., but all have the same transverse and longitudinal dimensions, namely 55 ft. 8 in. and 60 ft. on centers, and have the same details of bracing modified only by the varying dimensions. The faces are similar in transverse and longitudinal elevations, in each of which the tops of the vertical columns are connected by a horizontal lattice girder and by deep portal struts forming a continuous arch between the columns. The dimensions of the two bents of the same tower vary slightly, but the materials are alike. In successive towers both materials and dimensions vary perceptibly.

In the second tower from the entrance the tallest bent has a height of about 36 feet., and the lattice girders are 7 ft. 9 in. deep on centers, with a rectangular top chord composed of two 12-in. channels and a 34x9-16-in. cover plate. The bottom chord has an H-shape cross section made with two 12-in. channels connected with lattice on their flanges and by an intermediate horizontal diaphragm made with two continuous full-length angles latticed. The web members consist of X-braces each of which has an I-shaped cross section made with two pairs of 3x3½-in. angles back to back latticed. At intersections one member is continuous and the other is cut to clear and spliced with field riveted cover plates on both flanges. The curved portal brace has a rectangular cross section with two 17x⅜-in. web plates, one 25x⅜-in. cover plate, two 8x6x½-in. bottom flange angles turned inward, two 3½x3½x⅜-in. inside and two 4x4x⅝-in. outside top flange angles. The top flanges are connected by the cover plate and the bottom flanges are latticed. The web members connecting the curved portal brace with the columns and with the horizontal girders correspond to those in the latter member and are connected to rectangular extensions projecting from the face of the column.

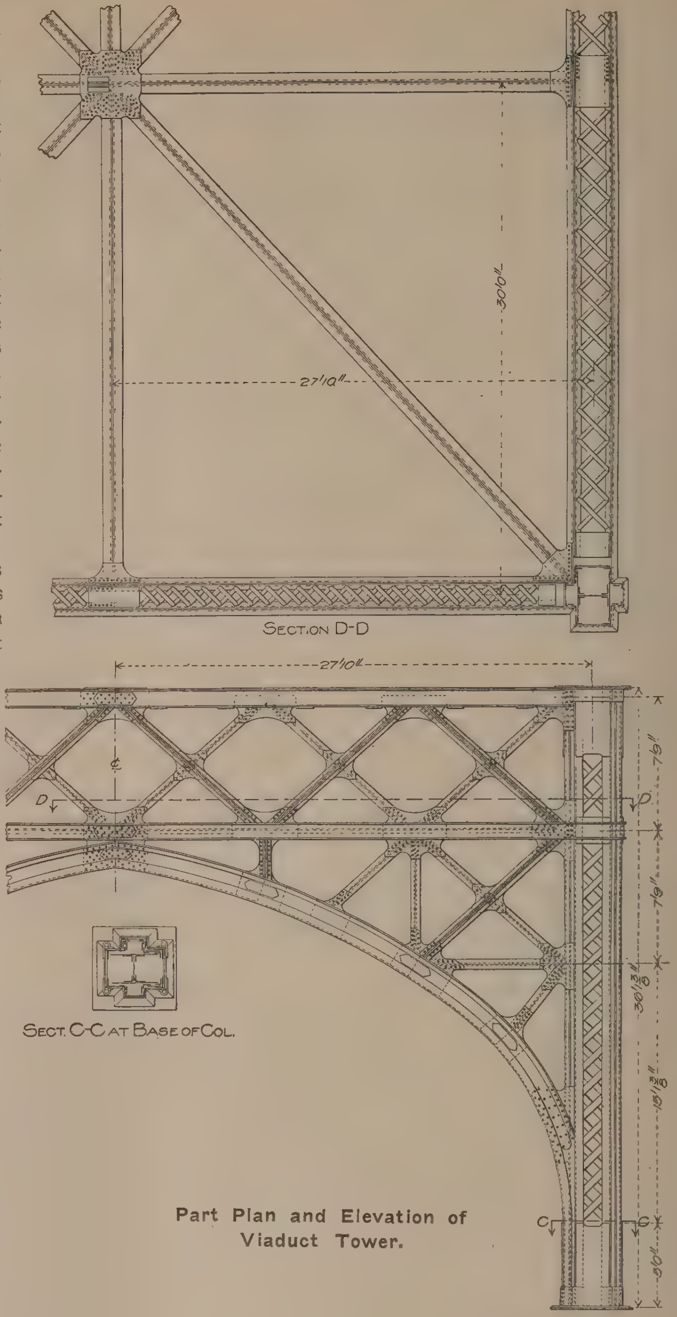
The column has a cruciform cross-section, closed excepting for narrow lattice spaces in each face, and is also provided with an interior I-shaped diaphragm in a plane parallel to the bridge axis. It is made in the heaviest bent with four 8x6x¾-in. outside and eight 4x3½x⅜-in. inside flange angles, four 8x6x11-16-in. web angles, for the I-shaped diaphragm, two 38x13-16-in., four 7x⅜-in., and one 23x½-in. plates. The foot of the column is connected by ¾-in. bent plates to the 58x1-in.x58-in. base plates seated on a cast-steel pedestal. The bottom chords of the longitudinal and transverse latticed girders are braced at their centre points by I-shape horizontal struts perpendicular to them, each made with two pairs of 6x3½x⅜-in. angles latticed and intersecting in a common point at the center of the tower with two main diagonals of the same panel. At the intersection the longitudinal girder is continuous and all of the others are cut to clear it and connected together and spliced with large field riveted top and bottom flange cover plates.

The single transverse bents intermediate between the towers correspond exactly to the bents forming the towers, except that the upper and lower ends of the columns are expanded longitudinally to form wider seats for the trusses and to secure extended bases. The construction is clearly indicated by the side elevation and cross sections of the 30-ft. 6-in. column in bent No. 64, which has a width of 5 ft. at the top and a width of 6 ft. at the bottom. It is made with eight 8x6x¾-in. and eight 4x3½x⅜-in. angles and four 38x⅜-in. and four 7x⅜-in. plates, the 7-in. plates have the small angles forming the wings. The shortest bents have a height of only about 12 ft. and 15 ft. and in them the horizontal girders are omitted, the columns being connected only by the curved portal struts and narrow top struts connected together with vertical and diagonal members so as to practically form spandrel braced arches. The cross sections of the column and portal bracing correspond essentially to those already described.

The cast-steel column bases have cruciform plans corresponding to the cross section of the columns and have a uniform height of 8 in. They are of cellular construction with a continuous base plate and vertical webs all 2½ in. thick. Both top and bottom surfaces are planed and the vertical webs are located in the planes of the column webs so as to afford them direct bearing without any horizontal top plates. Each pedestal has four 3-in. holes for vertical anchor bolts in the piers, and after its column is erected on it the pockets between the vertical webs are filled solid with concrete extending up into the base of the column.



Half Elevation of Typical Trestle Bent.



Part Plan and Elevation of Viaduct Tower.

The spans connecting the towers and intermediate bents are made with two lines of riveted trusses 25 ft. 6¼ in. deep and 60 feet apart on centers. The three spans in each panel between towers are duplicates except that the two end spans cantilever one panel beyond their supports on the tower to form half of the tower span. Except for the three spans at the shore ends which have two panels each, all spans have three panels, varying with the total length of 131 ft. 4 in., 145 ft. 6 in., and 165 ft. 10½ in. Except for these changes and the corresponding variations in material all spans are essentially duplicate and the details of construction and connections are alike throughout the approach. The spans between the first and second towers from the shore ends are 131 ft. 4 in. long on centers, with 21 ft. 10⅝ in. panel lengths.

Both top and bottom chords have rectangular cross sections made with a pair of built channels with their flanges turned inward and latticed. The maximum bottom chord section consists of four 6x4x⅝-in. flange angles, two 30x9-16-in., two 28x½-in., and two 22x⅝-in. web plates, giving a net area of 96 7-10 sq. in. The minimum bottom chord is made with four 6x4x7-16-in. flange angles and two 30x⅝-in. web plates, giving a net sectional area of 45.7 sq. in. The top chord is of similar construction materials and dimensions, with a minimum net area of 33 3-10 sq. in.

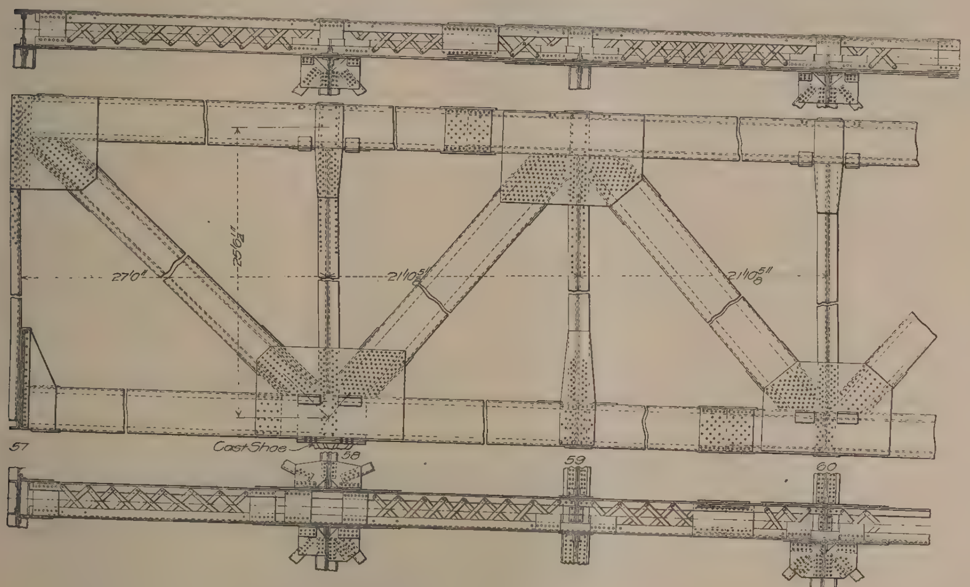
Both top and bottom chords are apparently continuous through the three spans from center to center of towers, but sliding joints with cover plates bolted on through slotted holes are introduced in the top chords near the intermediate bents to separate the spans and prevent continuous girder action in the trusses. The construction of the diagonal members is similar to that of the chords, being made with rectangular cross sections composed of two built channels with their flanges turned in and latticed, with a maximum cross section composed of four 6x6x½-in. flange angles, two 30x½-in., two 28x9-16-in., and two 18x½-in. web plates. The panels are subdivided by vertical posts having a uniform I-shape cross section made with four 7x3½x½-in. flange angles and a 23½x⅜-in. web plate.

All members of the trusses are shipped separately, the chords being made in two-panel lengths and having ¾-in. connection plates shop riveted to the backs of their channels at panel points and projecting beyond their inner flanges to serve as connection plates receiving the field riveted connections to the vertical and diagonal members. At the panel points over the intermediate posts supporting the center span, these connection plates serve as field splice plates for lower chords. At all other points top and bottom chords are spliced with six or eight web and flange cover plates field riveted to both members.

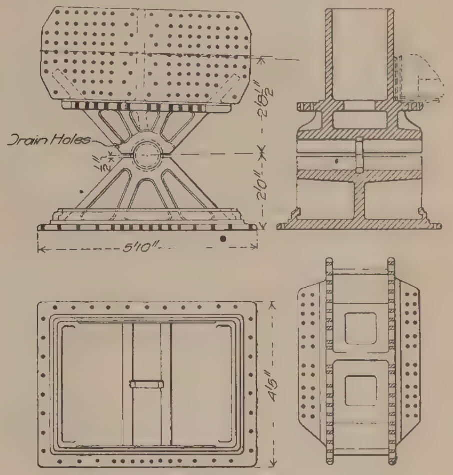
The trusses are connected at panel and subpanel points by the transverse girders in the upper and lower deck which are field-riveted to the vertical members with their flanges flush with those of the chords. At the girder connections the chord webs are connected by the vertical members of the truss which pass through them or by pairs of vertical transverse diaphragms which stiffen them and distribute the load through both of the built channels. In the lower chord these members also provide continuous connections between the main section of the floor beam uniting the trusses and the cantilever extensions on the outside of the trusses. Horizontal connection plates riveted through the lower flanges of top and bottom chords at panel points and to the floor beam flanges provide for the field riveted connnections of the single top and bottom lateral system diagonal angles. The trusses have no transverse vertical diagonals, but are sway-braced by the depths of the connections to the transverse girders and by the portal-like kneebrace brackets under the upper deck.

Over the vertical posts in the towers and transverse bents the trusses have bearings on 9-in. pins engaging half-hole bearings in cast-steel shoes and pedestals. The shoe differs from those ordinarily employed for the bearings of riveted trusses for girders in that it has, besides the horizontal bearing on the bottom flange of the chord, a pair of vertical web plates connected by an integral transverse diaphragm and engaging and riveted to the webs of the lower chords. Both vertical and horizontal bearing surfaces are faced and the rivet holes are drilled after the shoe is assembled to the lower chord, thus insuring absolute precision in the rivet holes.

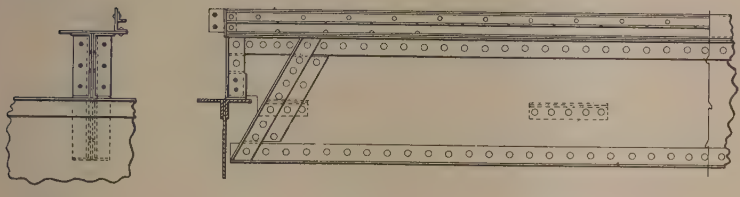
The continuous half-hole bearing for the pin is stiffened with longitudinal and transverse webs and has in the center a groove for a collar, which is also grooved into the pin and locks it in position. The pedestal has a similar half-hole pin bearing stiffened with one longitudinal and four inclined transverse webs integral with the wide base plate, 3¼ in. thick, secured to the tower or vertical post with numerous field rivets around the outer edge. The space around the webs is filled solid with concrete retained by a projecting fillet around the edge of the base plate, which is recessed to lock the concrete in position. At the expansion ends the height of the pedestal is made 7¼ in. less than at the fixed end, and it is seated on a nest of eleven 4-in nickel steel rollers 40 in. long, supported on a cast-steel bed plate 3 in. thick. The rollers are fixed transversely by center guide ribs and their shouldered ends engage the vertical flanges of angles carefully fitted to rebates in the end of the base plate and pedestal, thus excluding dust and rubbish from the rollers.



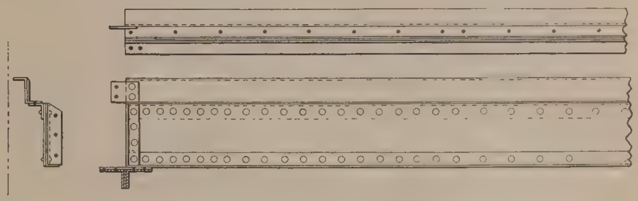
Cantilever End of Viaduct Truss.



End Bearing for Viaduct Span.



Drop End Stringer.



Cable Conduit Stringer.

The transverse girders in the lower deck are each made in three sections, one of them 58 ft. long between the trusses, with a 12-ft. cantilever extension outside the trusses at each end. The 58-ft. section has a 72½x7-16-in. web shop spliced in three lengths and a pair of full length 8x6x⅝-in. angles in each flange. The top flange has a single 24x¾-in. full length cover plate and the bottom flange has a full length 18x⅝-in. and a 34-ft. 18x½-in. cover plate. The girder is divided into 5-ft. panels by vertical web stiffener angles at the connections to eleven lines of stringers, all of which are plate girders with 27x28-in. webs. The four trolley stringers have pairs of 5x3½x⅜-in. flange angles and single full length 16½x⅜-in. top flange cover plates. The seven intermediate stringers carry the roadway at 3½x3½x½-in. flange angles without cover plates. All the stringers are web-connected to the web of the transverse girder and are seated for convenience in erection on horizontal bracket angle shelves and have the upper corners of their webs cut to clear the top flanges of the transverse girders.

A solid floor of ⅜-in. buckle plates is riveted to the top flanges of all stringers and transverse girders. The cantilever ends of the transverse girders are field riveted to the vertical posts of the trusses and are spliced to the main girders by pairs of angles on the top flange and by an 18x15/16-in. cover plate 7 ft. 9 in. long on the bottom flange. Their outer ends are connected by a continuous line of facia stringers made with a 45x⅜-in. web plate and a single 6-in. 15-lb. channel riveted to the outside of each flange.

The stringers for the outside trolley track are of special construction with a 27x⅜-in. web and 5x3½x½-in. flange angle. The top flange is reinforced by a 60½x⅜-in. cover plate, to which is riveted a 6-in. bulb angle reinforced by a 2x2-in. stiffening angle to serve as a guard-rail. The lower corners of the webs are notched to clear the top flange of the cantilever and give a bearing on it for the stringer web and allow the bottom flange to be seated in the usual manner on a bracket angle riveted to the girder web. The end of the lower flange is stiffened by a pair of inclined web stiffener angles and pillar plates.

The electric conduit in the center of the trolley track is made with a pair of built channels 13 in. deep with their flanges turned in and the upper one supporting the Z-bars forming the slot. The curb girder just inside the trusses has a rectangular cross section, made with two 15-in. channels, with both flanges turned in the same direction and connected by an 18x⅜-in. cover plate on top and by lattice bars on the bottom.

Transverse expansion joints are provided in the lower floor on the center lines of the towers. At these points there are double floorbeams 20½ in. apart on centers with special top flanges connected by a sliding apron plate. A full length trough made with 5x¾-in. plates riveted to the flanges of a horizontal 9-in. channel is riveted to the top flange of the fixed girder, and the space between the channel flanges is filled with asphalt hitched to one end and making a gutter to carry off drainage water from the pavement without danger of leakage to the road below. One edge of the trough has a continuous cast-steel bracket forming a sort of hinge connection for the checkered cast-iron apron plate 12 in. wide and 2 in. thick, with a convex checkered upper surface, which is made in sections about 5 ft. long. The outer edge of this plate is supported by and slides freely on the horizontal flange of a 6x8-in. angle riveted to the transverse movable girder and bearing on the upper edge of one of the trough plates. This arrangement provides for a movement of several inches, causes very little irregularity in the surface of the pavement and can be easily inspected, cleaned or repaired.

The specifications for the sub-structure and super-structure are very complete and correspond substantially with those already mentioned in the article descriptive of the Manhattan approach. The requirements for the structural steel and for the cement correspond to accepted standards and contain ample provisions for tests and inspections. All parts of the work are proportioned for expansion and contraction due to a change of temperature of 160° Fahr. and all rods and tapes used in laying out these works in the shops are carefully standardized with those used in the location work. Paint is mixed with 500 lb. of red lead to 19 gallons of pure linseed oil. The red lead must contain at least 80 per cent. true red lead and not more than 1/10 of 1 per cent. of metallic lead. It shall pass through No. 19 silk bolting cloth with a residue of only 1 per cent. Very complete specifications and descriptions are given for the track construction, electric equipment, rail joints and bondings and the creoresinade wood block pavement.

The principal quantities in the second section include about 17,000 cu. yd. of excavation, 35,000 yd. of fill, 8,400 yd. of concrete, 2,500 yd. of dry rubble retaining walls and coping, 4,900 yd. of granolithic concrete walks and foundations, 10,500 yd. of pavement, 3,900 lin. ft. of four-way electric conduits, 9,560,000 lb. of structural steel, 280,600 lb. of steel castings and 60,500 lb. of nickel steel castings, 172,000 lb. of steel rails and 173,000 lb. of cast-iron.

The bridge was designed and its construction supervised by the Department of Bridges of New York, Mr. J. W. Stevenson, commissioner; Mr. C. F. Ingersoll, Jr., chief engineer. The contract for about 1,420 ft. of the viaduct nearest the river was awarded to the Buckley Realty Construction Co. and the contract for the remainder was awarded to the Maryland Steel Co., who fabricate the structural steel work at their steel shop and who have sublet the contract for the erection and for the sub-structure work to the Snare & Triest Co., New York.

Ditch Construction on the Seward Peninsula.

The placer mining industry of the Seward Peninsula, Alaska, was developed at a very remarkable rate, the possibility of lucrative mining being established within about a year of the discovery of gold. The great drawback, however, was the absence of water, and though good sense and engineering judgment discouraged the construction of ditches, the rich field awaiting development promised a return on the heavy investment necessary to get water. Construction was first started in the Miocene Ditch, a project about 60 miles long, which carried the water from the head of Nome River across the divide to a point above the benches of the Snake River slope. The constructors had no precedent for such work in this climate, but by sheer grit surmounted all difficulties. The success of the enterprise ushered in an era of construction during which, in 1905, the ditch of the Taylor Creek Ditch Co., of New York, was built. The latter work was described by Mr. James A. Kelly, engineer for the company, before the Pacific Northwest Society of Engineers, in a paper reprinted in the September "Proceedings" of the society, from which these notes have been taken.

The data furnished to Mr. Kelly consisted of a profile of the proposed ground to be traversed, which plainly showed itself to be the work of the barometer and hand level, and a verbal description of the country. The date fixed for embarking upon the expedition was June 4.

Among the materials necessary were one-half mile of 40-in. No. 10 B. W. G. steel riveted pipe, 300,000 ft. of No. 1 clear fir lumber, surfaced four sides, and some few miles of burlap 12 ft wide; plows, scrapers and graders; sixty-five horses, twenty-two wagons, material for a suspension bridge and tons upon tons of provisions for the laborers and feed for the horses; 50 tons of coal; tents to house three hundred men, office tents and stable tents, the latter accommodating twenty horses each.

The pipe was nested, one section 5 ft. long, fully riveted, enclosing four other sections nested inside and bound with clamps of strap iron after the fashion of sheet steel. Hay was hydraulically compressed; sustenance for the men selected from the class of provisions generally conceded to be the most filling and nourishing for their weight. The material and supplies were sent by tramp steamship to Teller, at the mouth of Grantley Harbor, the main part of the expedition sailing to Nome with the horses, wagons and some few implements for the construction. The trip to Nome and unloading of boats occupied about 15 days. Then followed a wait of about two weeks to allow the horses to recover from the effects of the sea voyage and get acclimated; also to allow spring freshets in the rivers time to subside.

During the first week in July the expedition started out overland for the Kugorock River, a distance of about 150 miles. It tallied-up ten wagon outfits, each comprising six horses and two wagons and about twenty men, including drivers. From ten to twelve miles per day was the average haul, and that with only about 3,000 lb. load for six big horses and two wagons. Extra feed and provisions for horses and men were brought up by boats from Teller through Grantley Harbor and Great Salt Lake to Mary's Igloo, a distance of 65 miles, and from here on up the Kutsitrin River in horse boats to Lane's Landing, fifteen miles. This place was about half way between Nome and the destination and was generally used as a supply station for the surrounding country. The horse boats were usually about 26 ft. long, built scow fashion, but with a great deal of dish, and flexible enough to be twisted without breaking. They were pulled up stream by one horse.

The Peninsula is practically barren of timber, except for a few small clumps of cottonwoods and dwarf firs in river bottoms, and is for the most part covered with tundra. There were no roads in the country, and had there been, contrary to what is usual, the beaten track would be the thing to shun, it being always one continuous mudhole. On the 18th of July the expedition started down the slope into the Taylor Creek valley, and at noon camped at a point about the center of the proposed ditch line.

Transportation of the main part of the material was effected as follows: One supply station was established on the beach at Teller, and another one, to be used as a base, established on a navigable slough or arm of Great Salt Lake and named Kugorock. Here the party built a large warehouse and stable 60x80 ft., with a strip off each side used for stables for horses and the center for perishable supplies. A light draught stern-wheel gasoline boat provided with several scows was placed on the run between these two supply stations, traversing Grantley Harbor and Great Salt Lake and the aforementioned slough, a distance of 60 miles. From here on material was transported by wagon outfits up the bed of Mary's River to the summit, down Coarse Gold Creek to the Kugorock, and up the Kugorock to Taylor Creek, a distance of 45 miles, and distributed as required. The wagons were the common type of farm wagon, with perhaps all vulnerable parts a little stronger than is usual. One ditch company used an ordinary wagon with extra tires of steel 10 to 12 in. wide, shackled on over the felloes of the wheels, these tires sometimes preventing the wheels from sinking in the mud, but making matters much worse when they did. Another outfit would have nothing but narrow felloes and tires, with spokes widening toward the hubs so that if the wheels did sink more readily they would the more easily be pulled out. Wherever possible wagon trains took to the beds of streams, which, though full of boulders, at least had the virtue of being solid.

The methods of making the surveys were simple, being first the setting of stakes 1½ ft. above the proposed sub-grade of the ditch, the fall of which was only about 4 ft. per mile, owing to the necessity for developing head in as short a distance as possible and the danger from erosion in glacial ground consequent to high velocities. Following the level party, a hand level party reset the lower stakes to obtain some respectable appearance of curvature and allow for slope, at the same time setting upper slope stakes to conform. Slope was usually 2 to 1. The stake material was all of selectetd fir, 5 ft. long, 1½ in. wide, ¼ in. thick, surfaced four sides, and shipped in bundles of fifty each. On the ground the bundle was sawed in two and the stakes sharpened.

The ditch was to be some twenty odd miles long and designed to carry about 90 cu. ft. per second. It was broken in the middle by a crossing of Taylor Creek, in the form of an inverted syphon carried on a suspension bridge. Spillways were to be placed every mile or so of its length to regulate the flow of the water in the ditch, which would vary considerably owing to the surface drainage. Alternating with these spillways every mile were waste gates, permitting the water to be shut off entirely from the portion of the ditch beyond and allowing the section of the ditch thus isolated to be thoroughly emptied for repairs.

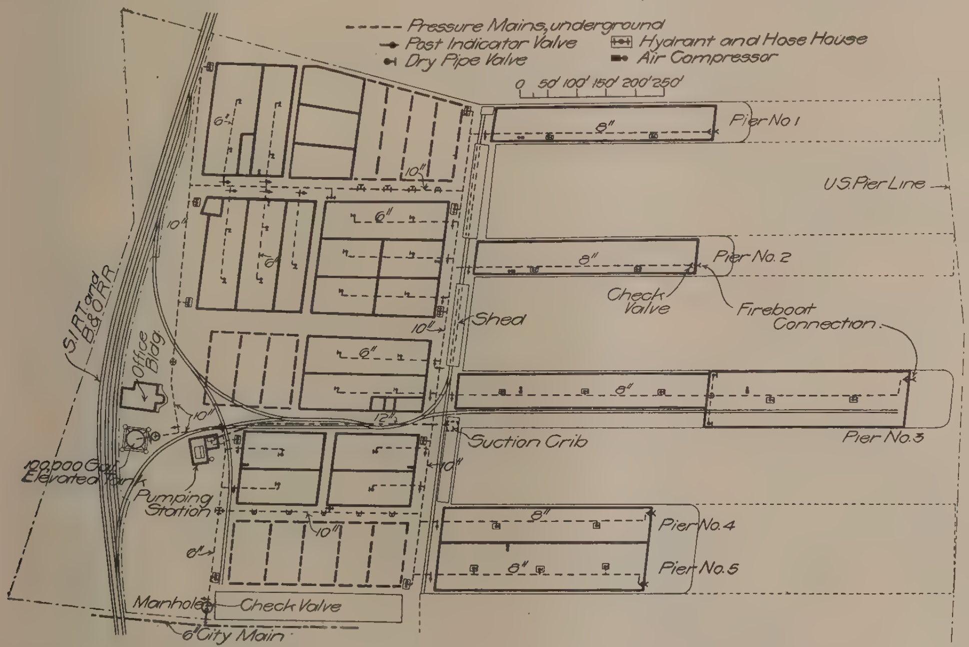
The working season being a short three months, dirt was flying before the first 600 ft. of stakes were set. The stakes being set, tundra was immediately plowed up between the lower slope stakes and up to a point directly over the bottom of the ditch on the up-hill side. This sod or tundra was dragged off by laborers with hooks made from miners' driving picks with the ends bent over, and if the sod was of any value at all as bank it was placed as such, otherwise tundra and light material was dragged down the slope to clear the bank. The ground thus exposed was allowed to thaw. In the glacial ground it thawed and sunk readily to a point below the sub-grade, then burlap was placed in the bottom of the ditch to prevent erosion and thawing, and covered with silt up to grade, the sod left on the upper side gradually dropping as the ground sloughed out from under, forming a protection for the upper bank against further thawing. In cases where the ground thawed unevenly an ordinary device similar to an old-fashioned snow plow, V-shaped, steel shod and well loaded with sand bags, was held against the upper bank and dragged along with horses, pushing the mud against the lower bank and evening up the bottom of the ditch. For ordinary dirt excavation, long-handled shovels and a type of horse scrapers generally known as "slushers" were used, six teams with scrapers comprising an outfit, with one driver, two loaders and two dumpers working in a circle crosswise of the ditch and dumping on the bank. When the ditch was roughly excavated by this means, it was trimmed up and sloped by laborers with shovels and mattocks.

The rock encountered footed about 20,000 cu. yd., and was for the most part perpendicular cliffs of mica schist, interspersed with stringers of quartzite, very soft and almost capable of being moved with mattock and shovels, but not quite, and Mr. Kelley states that after an experience of ten years and the personal use of hundreds of tons of high explosives, this rock is the worst to move he ever encountered, some innocent little shots tearing whole slabs of the cliff away below grade, while other big ones seemed to find their way into crevices and not accomplish anything. In places where no rim was left for the lower side of the ditch, sod walls built with all the care usually given masonry were placed.

Short pieces of flume were used across gaps, with aprons well sodded in, and sometimes burlap or canvas was used to make the joint tight. The foundation pits for the flume trestles were cut in the ground, mud blocks of cedar set and sills set on top, and as far as possible covered up with sod to prevent further thawing of the ground. These were left to stand a while and assume any position or elevation they chose, and trestles and flumes built on top. On the whole line there was about a half mile of flume.

It was intended to construct the dam of concrete, but legal obstacles prevented securing a favorable site and the dam was built of sand bags, sod and boulders.

The inverted syphon was constructed from the 40-in. pipe afore-mentioned, having a maximum pressure at the lowest point of 50 lbs. per square inch, and the pipe was supplied at each hump in the grade with automatic air valves, six in all, and in the center of the suspension bridge with a blow-off. The suspension bridge carrying the syphon had a clear span of 100 ft., and consisted of two 1¾-in. plow steel cables, 4 ft. 4 in. apart, one on each side of the pipe, from which yokes were suspended every 5 ft. apart. The main cables had a dip of 12 ft. at the center of the span, and were carried back 37½ ft. beyond the towers to anchors buried in the frozen ground. The yokes which were suspended between the hangers and carried the pipe were of fir, 6x16 in. x 5 ft. 4 in. Foot boards of 3x12-in. stuff were laid on the yokes on both sides of the pipe and guys of ¾-in. rope were run to shore in four directions from the center, and anchored with dead men frozen in. The towers were built of timber 19 ft. 6 in. high.



Warehouses and Docks of the American Dock Stores, Staten Island, N. Y.

The anchorage pits for the main cables were cut into the ice about 15 ft. by means of steam thawers. Dimensions at the bottom were 8x17 ft. Here a mattress was placed consisting of 12x12-in. plank 17 ft. long, and on top of this cedar planks, 3x12 in. x 8 ft., placed crosswise. The main cables were secured to these by means of a number of loops from the flexible small cable and water and mud poured in until the pit was filled up and the holes allowed to freeze again before the false work for the bridge was removed.

By the term "glacial ground" in this article is meant ground with a covering of moss or tundra a foot or two thick, with a stratum or deposit of mud and black peat from 2 in. to 1 ft. thick, and below this from 10 to 40 ft. of ice holding in suspension perhaps 10 to 20 per cent. of silt. Under normal conditions the peat or mud thaws in the summer time a foot or so, but in some places not at all. It was observed by the pioneers, however, that there was less liability to encounter ice on the south slopes, hence frequent crossings from one side of the valley to the other were resorted to.

Steel Cross-Ties of trough section placed 6 ft. on centers have been used on about 75 per cent. of the city lines of the Montreal Street Ry. Under each line of rails there is a concrete beam, while between the beams there is the usual concrete foundation for the pavement.

Fire Protection System of the American Dock Stores.

By Frank Sutton, Consulting Engineer, New York.

It has only been during the past few years that the question of some adequate means of fire protection has been adopted. While it is true that the sprinkler head has been used for some time, it has been confined almost entirely to manufacturing establishments, and even then to a limited extent, the owners of buildings having depended largely upon the fire departments of the towns in which they were located. Of late years the importance of some adequate and reliable means of extinguishing fires has been realized, and to-day a large number of manufacturing concerns are endeavoring to provide complete systems of fire protection.

The credit of bringing this branch of engineering up to its present state of perfection is without doubt due to the New England manufacturers, who long ago realized that it was to their advantage to provide some suitable form of protection, and their example has been steadily followed, until at the present time the sprinkler and fire protection business has grown to a very large extent, although, strange to say, this particular line is confined to a small number of concerns who make a specialty of this class of work. This is without doubt due to the fact that the underwriters have been very stringent in their requirements as to the design of the sprinkler head, which is the important factor in an up-to-date fire protection equipment. Then, again, the question of patents has entered largely into the design of heads, and at the present time it is a difficult matter to design a new head which will not infringe on some article already being manufactured. Even up to this time designing engineers have paid much too little attention to this question, the work having been left almost entirely to the sprinkler concerns to design the systems which are installed.

Another important feature in connection with this class of work is not only the advantages gained by protecting the property against loss by fire, but also the large reduction in the rate of insurance, varying from 30 to 50 per cent. reduction for a sprinkler equipment. The writer has known of cases where in a first-class equipment the insurance is carried for from 5 to 8 cents per hundred, which is extremely low. These low rates are confined mostly to the mutual companies, which are in the majority of cases more stringent in their requirements and will only assure what might be termed preferred risks, such as factories of certain construction and manufacturing certain lines of goods, and in some cases docks and warehouses, and will only accept risks that are protected with sprinkler equipments.

Sprinkler systems may be divided into two classes, wet pipe systems and dry pipe systems, the wet pipe system being used and being required for all purposes where the lines are not exposed to freezing. It is only in cases where the pipe is exposed to low temperatures that the dry pipe system is installed.

The principal differences between these two systems is that in the wet system the piping up to the sprinkler head is full of water. The dry system is supplied with air in that part of the piping which is exposed to freezing temperature. This is accomplished by keeping a pressure of air in the lines a little above that of the pressure in the water pipes and interposed by a specially constructed dry valve which operates when a head discharges, thereby relieving the air pressure and allowing water to flow through the lines. The illustration shows a dry valve which is used by one of the sprinkler concerns. These valves are all constructed on similar lines and are fully protected by patents.

To install a first-class fire protection system there should be at least two sources of supply and preferably three; that is, three distinct sources from which water may be drawn. One source is the sprinkler tank, located at some distance above the highest sprinkler head, and another source is the supply of water furnished by some public water works, either getting direct pressure into the system or operating through a fire pump. Other sources may be either a lake or a river, or artesian wells or springs, depending upon the location of the building. It is also sometimes customary to build a large reservoir, underground or outside, holding anywhere from 100,000 to 500,000 gallons, that may be drawn upon as required.

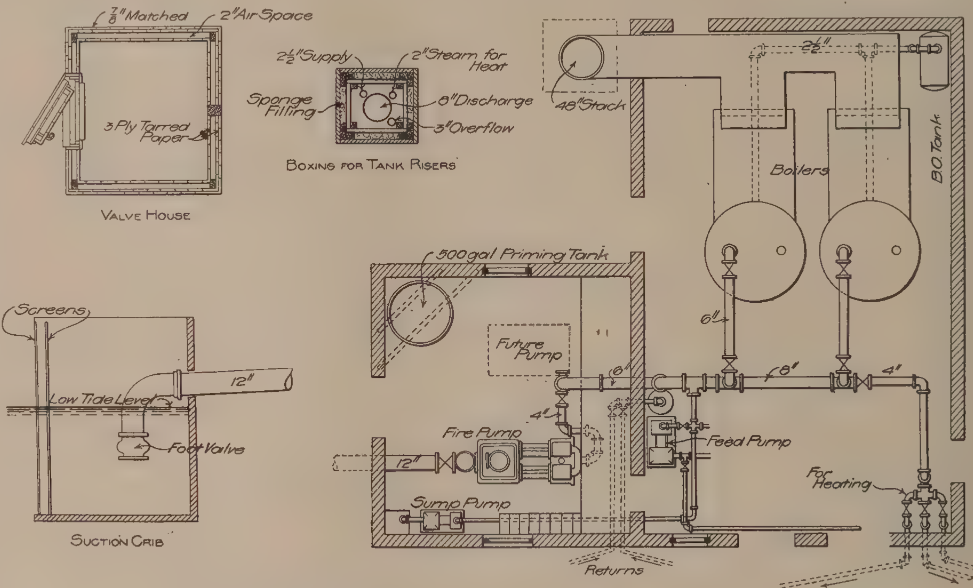
The insurance people, especially the mutual companies, insist on two sources, namely, a sprinkler tank and a fire pump if the street pressure is not great enough to carry the water to the highest sprinkler head. Where a steam fire pump is installed it is obligatory on the part of the assured, especially in mutual risks, that the boiler plant be kept under 50 lb. of steam at all times, so as to assure ample protection in case of fire. The electric fire pump is used to a considerable extent, but is not considered by the underwriters so good as a steam pump, on account of the danger of the pump motor being put out of commission either by water or by the breaking of electric wires.

The wet pipe system is by far the simpler of the two systems to install, as no complicated dry valves, air compressors or the like are required. The two systems, however, operate practically the same; that is, whether a dry pipe or a wet pipe system is installed the underwriters will require the same sources of supply and the equipment installed in the same manner, as far as the spacing of sprinkler heads is concerned, and the sizes of pipe used in connection with the installation of the system.

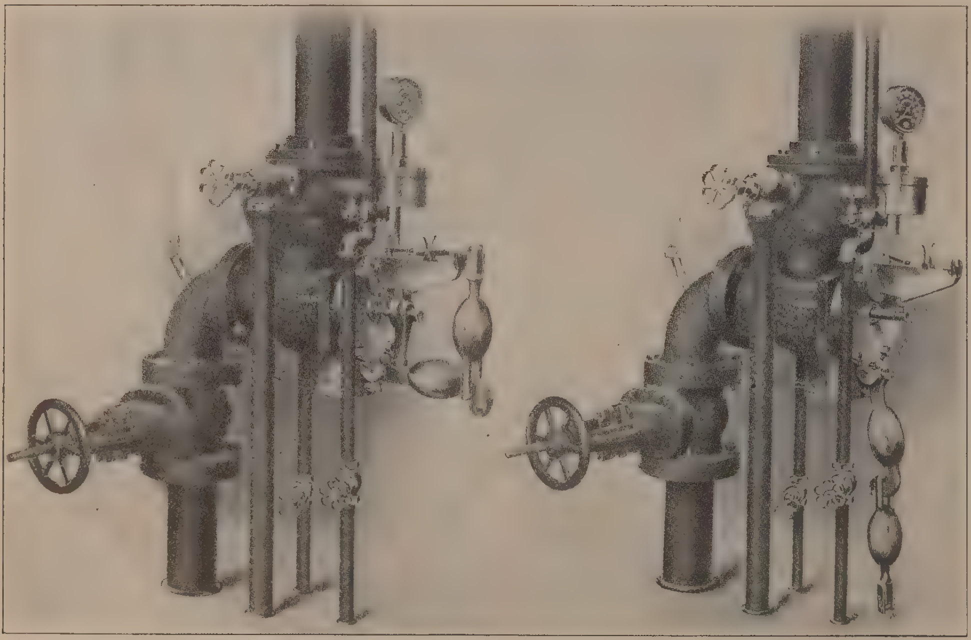
The following description of the fire protection system installed in the extensive docks and warehouses of the American Dock & Trust Co., at Tompkinsville, Staten Island, on lower New York Bay, gives an idea of a thoroughly up-to-date dry pipe system. In buildings of this class it would have been impracticable to install a wet pipe system, on account of the danger of freezing the lines, as neither the piers nor the warehouses have any heat whatsoever, and, in fact, the underwriters particularly stipulate that no heat shall be installed in any public warehouse. It became, therefore, necessary to install a dry pipe system throughout.

This particular system has three sources of supply, namely, a 100,000 gal. sprinkler tank erected on a 100-ft. tower, a supply from the Staten Island Water Co., running full 6 in. into the property, and a 12-in. suction line, running from the Lower Bay to the fire pump. It can be seen that from these three sources the property in question is assured without doubt of always obtaining at least one source of supply in case the other two are for any reason out of commission in time of fire.

A specially constructed brick and concrete pumping station has been located at the back part of the property on a line of the Baltimore & Ohio R. R., as shown on the plan. The boiler and pump rooms are divided by a brick partition, and a fire pump has been placed at a level about 6 ft. below the grade to assure a good suction from the Bay at low tide. The plant consists of two 150-h.-p. Fitzgibbon boilers, designed for a working steam pressure of 125 lb., which, however, is only used in cases of emergency, where the pump is required to work at its maximum duty. There has been installed one 1,000-gal. Worthington standard duplex fire underwriters' pump, having a 12-in. suction and an 8-in. discharge. The pump is also fitted with four independent 2½-in. nozzles, with gate valves for drawing four streams from the pump house in case of necessity. The boiler plant is fed by a duplex pump and also an injector to assure the boiler being supplied at all times. Ordinarily anthracite coal is used for running the fires, but a supply of cannel coal is always kept on hand, so that in case of emergency a high steam pressure can be developed within a very short space of time.



Details of Pumping Station for the Fire Protection System.



Closed and Open Positions of the Dry-Pipe Valve.

Around the suction line where it enters the water a large yellow pine crib has been erected, with two iron screens placed on one side. The crib was necessary, on account of the large amount of seaweed and other material which would get into the suction if the line was dropped directly into the water. A 12-in. foot-valve has been placed on the end of the suction to keep the suction line always full of water and to safeguard against having the pump start on a practically empty line.

A complete system of cast iron high-pressure service mains, ranging from 10 to 6 in. in diameter, has been laid through all streets and alleys. This line feeds the hydrant system and also the sprinkler system. The underground system is connected with a 10-in. drop riser, running from the sprinkler tank into it, and a 6-in. service pipe, running from the mains of the Staten Island Water Co. The discharge from the fire pump also empties into this line. Standard two-way underwriters' hydrants have been placed at intervals of about 200 ft., and at each hydrant is a complete hose house, equipped with standard underwriters' cotton hose, lanterns, wrenches, nozzles and other appurtenances required by the underwriters.

The warehouses and piers are equipped with a complete system of dry sprinklers, there being at the present time about 7,000 heads installed. Each warehouse and pier is separately controlled from the underground system by a post indicator valve located outside the building. The main continues from the post valve under the floor of the building and connects inside the building in a valve house, with an automatic dry valve. This is the point where the air pressure on the sprinkler system starts, the valve acting as an interceptor between the water and the air. These houses are kept heated in the cold weather by lard oil lanterns to prevent the water from freezing. The sprinkler system itself is kept at an air pressure of about 45 lb. in this particular case and is supplied from a system of air lines, which start from the boiler house and are connected to a New York Air Brake Co.'s duplex, locomotive type air compressor, steam driven. The air compressor is automatically operated by a governor placed on the steam inlet to the compressor and set at 45 lb., which starts the pumps when the pressure falls below this amount.

In case a sprinkler head is set off it can be readily seen that the pressure in the line is immediately relieved, and the water forces its way through the system and discharges at the head.

In addition to the dry sprinklers there has been installed a water curtain wall around the sides and fronts of all piers. This curtain wall consists of open sprinkler heads, set at a distance of about 8 ft. apart and divided into sections of about ten heads each, each section being operated by an independent valve, located in the valve house on the piers. This curtain wall is for use principally in case a steamer or lighter should take fire while tied up at the pier, so as to protect the pier against damage by fire.

In connection with this equipment a complete electric signaling system has been installed, with an annunciator placed in the pump room and connected with each valve house, so that in case a sprinkler head is set off the signal will be given in the pump room, locating the exact section of the discharged head. In addition to this system of electric signals, a water-motor gong is placed outside each building, which gives a further indication of the discharged head in that section.

The property is patrolled night and day by a force of skilled men, who take hourly readings of all instruments and conditions of valves and other apparatus in connection with the plant.

The system as installed has been made as complete as possible, and no expense has been spared to bring it up to a thoroughly up-to-date condition. It was only after several disastrous fires at the American Dock Stores, which did considerable damage to the buildings, that it was decided to install some system of fire protection. The entire sprinkler and hydrant system, as well as the steam plant, was designed by the writer, and installed by the Manufacturers' Automatic Sprinkler Co., of New York.

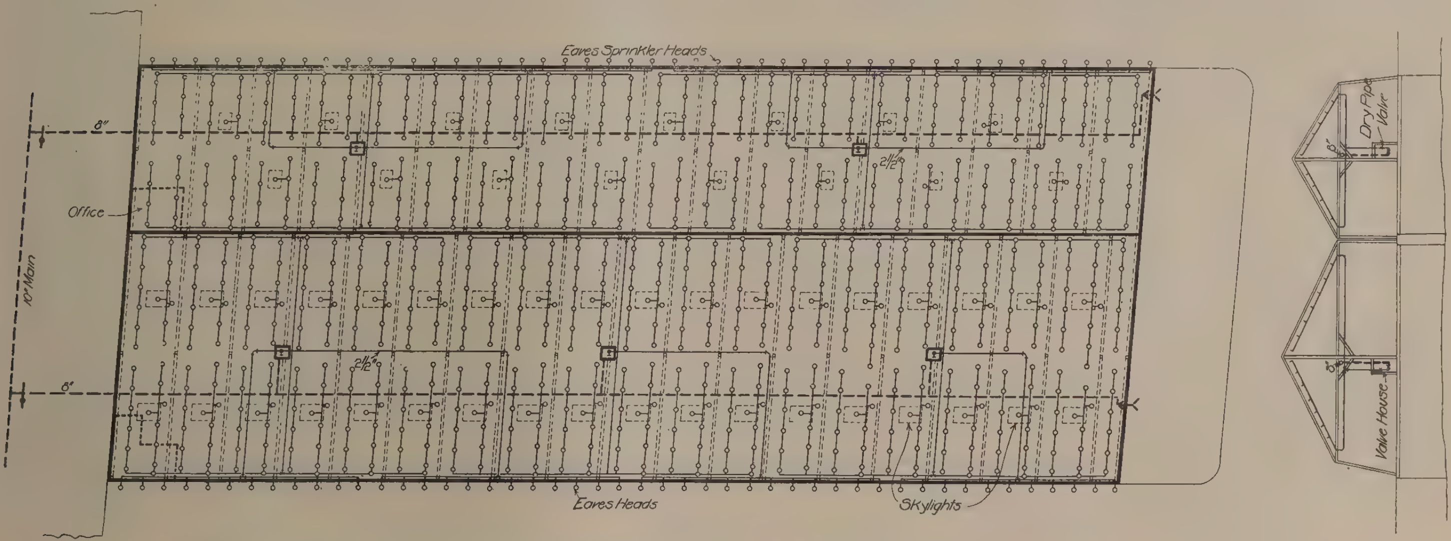
Reforesting Mineral Lands in Michigan is being taken up by the Cleveland-Cliffs Iron Co., which proposes to plant 14,000 acres.

Secrecy in the Arts.

Extracts from a paper by James Douglas, LL.D., presented at the Toronto meeting of the American Institute of Mining Engineers.

The title which we have assumed claims for the sphere of our activities the whole American continent, regardless of such trifling details as boundary-lines. The fact that we meet to communicate each other's experience, to discuss our difficulties, and to seek each other's aid in solving the intricate problems that so often present themselves in the course of our professional life, is an acknowledgment of our individual helplessness; and therefore an argument for united effort. But no effort can be of any value if there is an underlying suspicion of reserve and lack of candor in our treatment of the technical questions which it is our province at these meetings to discuss.

Yet there are limits to the extent to which we may go as officials of public companies. We know that even as professional men it is not always easy to reconcile principles with practice, and on this subject of sincerity and transparent diffusion of our experience there is some slight difference of opinion and difficulty of application. The most of us are paid officials of corporations whose *raison d'être* is to make money, and whose executive officers sometimes, not without some reason, consider their trade secrets as part of their capital. Some companies confide these secrets to the honor of their technical workers under as strict rules as those imposed on their cashier in the distribution of their money. Unless, therefore, our employers permit, we as employees are under pledge of secrecy.



Typical Lay-out of Mains, Valve Houses and Sprinkler Heads on Piers 4 and 5, American Dock Stores.

If the question were left to us alone, it would be easy of solution. Our reliance on one another, as workmen in such distinct branches of engineering as civil, mechanical, electrical, and mining, is so close that we must co-operate in every large enterprise we undertake. We cannot succeed singly, for few of us claim to be so encyclopædic in our knowledge or universal in our experience as to make it safe to rely on our own acquaintance with the practical details of every one of these important departments. Every industrial advance brings us closer together and makes it more impossible to act independently.

I think, moreover, that many of us are also convinced that open-mindedness to the suggestions of others is a useful quality to carry into our work, even after we and our scientific staff, in our joint wisdom, have co-operated in formulating and laying out our plans. Every draftsman in our offices, every master mechanic in our shops, every foreman in our mines, is an expert in his particular line, and may be supposed to be familiar with minutiæ which have escaped our observation, or, to put it frankly, may know more than we do ourselves on some of the innumerable details which make up the sum total of the questions on which we have ultimately to pass.

I recently went into our purchasing department and found every desk empty, and all the clerks assembled in the manager's room. He had found it conducive to the most efficient conduct of his office to assemble all his staff once a week for free discussion as to the most economical distribution of work. The result was that instead of late hours and overtime the necessary day's work was obtained very easily within office hours; for suggestions from the men actually engaged were found to be worth more than those from the men merely superintending.

How far and how completely should even corporations and industrial concerns permit and encourage the interchange of information? I am inclined to think that few limits should be set; for every limitation means the concealment of some fact or some principle which only if revealed can be developed to its full significance and utility. As a rule this can be best done by the action of many minds and many hands. Till developed it does not yield its full advantage to even the original discoverer, for he alone, unaided, in the solitude of his laboratory or behind the bars of his factory, without the practical assistance of his fellow-workers, rarely brings his original germinal idea into efficient, practical utility.

Were we free to appeal to purely altruistic motives, it would therefore be superfluous to argue in favor of complete knowledge- and experience-sharing, but profit-sharing is after all the impelling motive of industrial advance to-day, as it has been in all ages, and to reconcile the admitted evils of secrecy with the admitted advantages of publicity, the patent laws have been framed. They have always given the patentee the right to use either in his person or through his agent his invention or discovery for a limited number of years, provided he describes it so fully that it can be practiced by one skilled in the art. The publicity and knowledge conveyed by the specification stimulates the inventive faculties of others, and patented and unpatented improvements, along the line of the original invention, demonstrate both the value of publicity and the cupidity of men, even of the technico-scientific class.

It is foreign to my purpose to discuss the patent laws, except casually as they bear upon the subject of secrecy in the arts. One's thoughts pass with pleasure from the contemplation of money-making inventors and investigators to such prophets and apostles of science as Sir Michael Faraday. Sir Michael's profound and original investigations into electricity and magnetism gave the world the dynamo. Though he did not work out the mechanical details of a practical generator, he undoubtedly invented appliances which might have been used for making a strong basis-claim for a patent. But nothing could have been more repulsive to his spirit or foreign to his high aim in life than gauging his time and talents by a mere money standard. He lived contentedly on the small salary he received from the Royal Institution, preparing his lectures to children with as much care as he bestowed on those delivered before the Institution which made him famous; and turning his great learning and power of investigation to the nation's good in return for very scanty remuneration, for he deliberately decided to devote his life to scientific research for truth's sake, rather than to use his vast attainments in the service of Mammon. At the commencement of his career, Faraday added to his salary from the Royal Institution by what he called commercial work. At first, his average earnings from this source were £240 per year. By 1831 they reached £1,090. By 1838 they had shrunk to nothing; for in the meantime his great discovery of magneto-electricity was made, and his thoughts were so intently directed to his experimental work that no time could be spared for money-making.

But to descend to a lower plane. If it is the fact that technical science has progressed of late with unwonted speed through the co-operation of many workers, and that this co-operation has been made possible by the publication and exchange of ideas and experiences in the technical and scientific journals, would not our progress be even more rapid and thorough if all barriers of secrecy were broken down, and every encouragement were given to our techinical workers to describe in print and by conference, their notions and their actual experiments?. This is the attitude of some, I may almost say of most, of our large concerns, but unfortunately it is not that of all. It is impossible to compare, as to efficiency and profit, works the gates of which are fast shut, and in which obscurity and secrecy are imposed and practiced, with those to which free admission is granted and in which freedom of information is encouraged. But the following reflections force themselves upon us in this connection.

We know that very few technical papers issue from certain establishments; that on their officials silence is imposed; and that to these works inquisitive visitors are politely but peremptorily refused admission. There are not many such, but they are and have been very successful. But suppose that in imitation of their practice and regulations all were tempted to adopt it, so that the same policy became universal; what a sudden paralysis of industry would follow! Our secretaries would find it difficult to fill even their shrunken volumes of transactions with papers worth printing; our students would have to content themselves with the antiquated learning which their professors could supply; for there would be no more summer classes for practical work in mines, smelters and electrical factories, and the professors themselves would have to learn from old books. Every manufacturer and smelter would be obliged to bribe his neighbor's workmen and tempt away his neighbor's superintendents for information. As a result, before long, the very works which now find it so profitable, or think they do, to tap their friends' stock of knowledge and experience, and give nothing in return, would be driven in upon their own resources, and would undoubtedly then find them not so complete as they imagine. Of course, I am supposing an impossibility, because the spirit of intellectual freedom in our professions is too strong and too widespread to submit to such a tyranny, and because, before such darkness of ignorance had settled down on our great industries, the most pronounced advocates of secrecy would feel and acknowledge the ultimate consequences of concealment, and would become reformers.

This is a temper of mind foreign to a new country like ours, whose special industries have not been established long enough to wear grooves of rigid practice and sink into ruts of self-satisfied indifference. About the best correction we can apply to the growth of dry-rot is the banishment of secrecy. A curious instance of its blighting influence is seen in some of the older, not the newer, industries of the old world. The iron- and steel-works of Europe have not kept pace with ours in size and production, but the ironmasters of Great Britain and Germany, in coke-making and in blast-furnace economies and in steel-making processes, have been our teachers. Nor have they been shy of communicating their improvements, or, through jealousy of our success, slow in adopting ours. No nobler monument of international comity in thought and experience exists than the seventy volumes of the "Proceedings of the Iron and Steel Institute." And with few exceptions the iron- and steel-works of England, Scotland, Germany and France are open to any accredited worker in the same domain.

Yet before England was conspicuous as a maker of iron, she was famous the world over for her copper and tin production. But, between self-conceit and the inbred habits of trade-secrecy, her copper-smelting industry has fallen from its high estate. And it is not accidental, but linked as closely as any effect with its cause, that this decline is in great part the result of habits of secrecy which grew with the growth of age. At Swansea, every gate of the smelting-works is guarded, and as a result it has been as difficult for thought to escape out as for suggestions to find their way in. Swansea should still enjoy the leadership which her skilled labor, splendid coal and commanding maritime situation put within her reach; but she has preferred to gloat over her secrets behind closed doors rather than go out into the world in search of new business as well as technical methods, while also inviting the world to enter and exchange ideas with her. What is the consequence? New Zealand copper comes here to be refined, notwithstanding the first practical application of electrolysis to metals was made by Elkinton in England, and the Vivians adopted the Manhès method before Farrell introduced it into this country.

There are, however, of course, exceptions in England to this too prevalent habit of secrecy. To the works of the Rio Tinto at Port Talbot or of the Cape Copper Co. at Briton Ferry in South Wales, where metallurgical novelties have been tried, introductions are not refused. But the alliance of decay and suspicion in the instance I have given can hardly be accidental; and we may be sure that what is baneful in its effects in Europe is not likely to be beneficial here; for while the Atlantic separates continents it does not delimit the operation of laws.

In political life, vitality is maintained only when every man takes his full share as a debater in the discussion of political questions, and as a voter in the determination of state affairs. So in scientific and technical matters, the banishment of deceit, mystery and jealousy, and the freest admission of daylight by means of the unreserved diffusion of information through the press and personal intercourse, will instill into the whole body of workers a feeling of healthy rivalry, which, while stimulating their mental activity, will correspondingly benefit the financial interests of their employers.

I have supposed an extreme case—that the example set by our few secretive establishments were followed by all. Let me imagine a more probable issue, such as, I believe, will result from the fellowship of knowledge and experience which Mr. Carnegie, in presenting to our national engineering societies their new home, urges them to cultivate—namely, that all our technical manufacturers will learn how they gain, and not lose, by encouraging their staff-officers to study their neighbors' methods, and by throwing open their own establishments, in turn to the freest criticism of their competitors in trade. What will result? Nothing but advantage, I believe, to all whose wisdom and means have enabled them to provide themselves with the raw material of manufacture on advantageous terms, and to locate their works or factories at localities favorable for economical operation. Loss only to those who, in any case, ought to go out of business, because they have failed to secure the conditions essential to success! And, above all, benefit to the public, which, after all, is the finality we should always keep in view.

How, now, can these two cardinal conditions —financial success and public approval—be best attained? Unquestionably, by mutual help and the most unreserved publicity. In any branch of industry, no intelligent worker claims that he and his staff have attained either the utmost economy in operation or the most thorough acquaintance with all the reactions which may enter into the processes which he practices. Each knows that hundreds of other intelligent and well-informed men are eagerly at work on the solution of the same problem. Some may be a little cleverer than others, and some may have made a little more progress in certain lines than their co-workers. But this discrepancy will not necessarily continue; for the clever fellow is picked up by rival works, the secret so carefully guarded leaks out, and the disturbed average of paid ability and of stock of knowledge is restored. But if the companies and their staff are unwilling unreservedly to pool their knowledge and experience, the advantage of making into one great stock such accumulated experience and knowledge of these hundreds of workers is forfeited. With certain reservations, and by special permission, many of our larger establishments, in all or in certain departments, are freely open to each other's technical officers; but instead of being admitted upon sufferance, they should be invited in, with full liberty to study processes and test machinery; for assuredly the host would benefit as much as the guests by the discussion which would follow such unreserved exchange of ideas and comparisons of appliances and methods.

I have referred to certain limitations to publicity. One, undoubtedly, is costs. Under our present economic system, no manufacturer or miner or metallurgist cares to give away his costs, and that for very obvious reasons. What they are may be inferred, but professional courtesy forbids direct inquiry into that delicate subject. This restriction, however, need not interfere with unstinted technical freedom of intercourse.

There is, moreover, an additional judicious limitation to publicity. Most of our largest concerns are incorporated and financed as joint-stock organizations, in which thousands of technically ignorant and helpless shareholders are interested. Unquestionably, indiscriminate admission to works and mines must be refused, for, unfortunately, there would be visitors who, if admitted, after the visit would tell remarkable stories, from actual observation, with the view to affect the value of stocks. But such restrictions do not affect the main proposition that mercantile concerns of every class, depending for success on technical knowledge and skill, would gain by the removal of restraint on the thought and action of their technical staff.

I am not blind to the fact that the same object is sought to be attained by the consolidation of many works under one organization, or by the encouragement of friendly financial co-operation among even competing companies; but this tendency to consolidation has not yet succeeded in obliterating competition, and will not as long as there are active, intelligent men among us, who prefer to rule rather than to be ruled, and to manage their own business rather than have it managed for them.

On the benefits or disadvantages of the present movement towards consolidation of works and the combination of capital in large industrial undertakings, there is, and will be, of course, considerable diversity of opinion. That competition is wasteful and is encumbered with other evils few will deny; that it has a keenly stimulating effect all will admit. Yet it remains to be determined whether a board of absentee managers and paid officials will be a compensating substitute for the ambitions, personal pride and tireless energy and skill of the individuals who have built up great works which they may have seen, perhaps reluctantly, absorbed into a combination. There are, apart from the political and sociological aspects of the present consolidation tendency, technical and economical conditions which force themselves upon the consideration of those of us under whose management works have grown from small to large dimensions. The difficulty of maintaining a high standard of quality as the demand is made for enormously increased production is urgently presenting itself both to the management and to the public. And it is doubtful whether, after expansion has reached the point where administration charges become light, there is actual economy in unlimited expansion; and whether the most skillful and closely managed corporate organization can replace the personal supervision of a single mind. But what immediately concerns us in the present discussion is the dangerous temptation to adopt secretive methods by very large corporations.

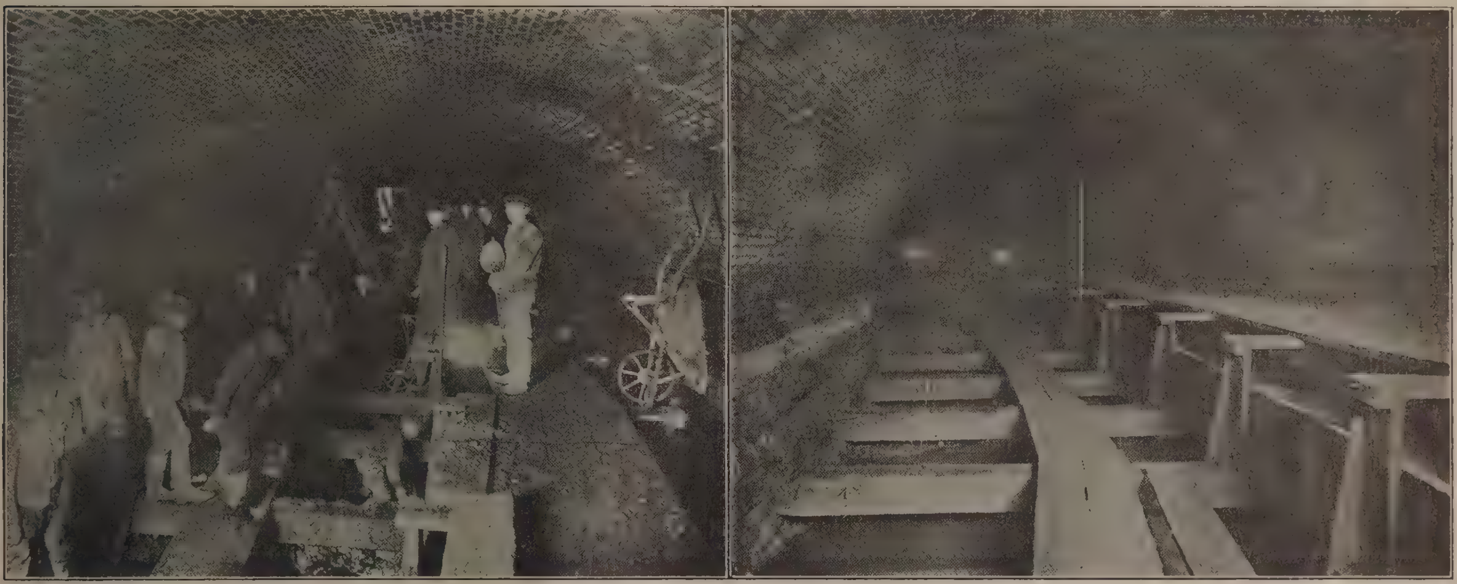
The larger the combination grows the more sensitive will the management be lest business and trade secrets which they possess, or think they possess, be revealed by subordinate officers. The imposition, therefore, of strict rules of silence on all except those in supreme command is likely to result. If the absorption of any one class of our national resources should pass under the control of any one organization, the technical knowledge necessary to the development of that particular resource would be of interest to that organization alone, and the risks of publicity, and therefore the evils of secrecy, would become a merely academic question. This dangerous point, under our present industrial system, will probably not be reached; for state socialism, to which concentration steadily approaches, would be the inevitable alternative and would be adopted before the other alternative had been attained. But it must be to the management of those enormous consolidations a grave consideration how they can give such latitude to the members of their staff as will produce that healthy self-reliance which comes from freedom of speech and freedom of opinion, without endangering the tremendous financial interests for which they are responsible. Whatever individual difference of opinion on this subject there may be among the managers of the great industrial establishments, there is not any difference of opinion in the country at large; and public opinion has to be consulted. Therefore, would it not be safer and better for the interests of the shareholders to adopt the policy of freedom which I have outlined, and thus placate the public? For the growing public anxiety, amounting to animosity and suspicion, against our big corporations would be allayed if it were apparent that the technical officials of the small concern had at least the right of knowing what the big concern was doing, and the big official did not arrogate to himself the possession of exclusive knowledge and exclusive skill. From the point of view of public policy, the question is one well worthy of consideration; for it is coming about that not only railroads, as public highways, but all large corporations utilizing the country's natural products and converting them into necessary objects of trade, will pass under closer legislative scrutiny and public criticism in the future than they have in the past—a necessary limitation, which will become more exacting the larger the corporations grow—if the tendency to growth continues.

While unquestionably dangers can be foreseen as arising out of these great industrial aggregations—not only of capital but of industrial energy—dangers technical, social and political—there are also great possibilities of good. One of the benefits may justly be claimed to reside in the large funds that are thus rendered available for technical research, from which the public derives benefit indirectly, even if the results are not published. But if we could banish secrecy; if every industrial establishment of any magnitude, which is in its own interest carrying on technical research, should encourage its technical staff to confer freely with the members of every other technical staff, would not the sciences and arts progress far more rapidly than if one huge organization controlled a given industry? All our principal metallurgical and chemical concerns have laboratories, and carry on investigations and make experiments, generally on a large working scale; and surely the advancement of technological science can be better attained in a number of such laboratories than if there were fewer or in only one. There is keener competition of wits when many brains are working independently. The friction of honest rivalry is a force not to be despised. The stimulus of ambition is sure to be stronger in smaller than in large consolidated workshops. The air in such laboratories is freer and purer than when men are working in the stifling atmosphere of secrecy. I believe that such a consolidation of mind and high impulses would carry us further and faster along the road of human progress than all the money that all the trusts could appropriate for the advancement of technical knowledge.

Buttressed Masonry Dams continue to be constructed from time to time, chiefly as extensions of old structures, and it is considered likely by a number of engineers that the type will find more application as a result of the present rapid increase in favor of the buttressed concrete retaining wall. For this reason mention may be made of a detailed analysis of such dams presented earlier in the year to the Institution of Civil Engineers of Ireland by Mr. M. T. Ormsby, and recently printed in Vol. 33 of its "Transactions." The final results of the study give the leading dimensions of such structures up to 40 ft. in height, in which there is no tension in the concrete, and the resultant force makes an angle of 35 deg. with the vertical. With the dimensions he gives, the maximum pressure at the toe of the buttress works out to 6.29 tons per square foot in the higher dams, corresponding with a maximum vertical pressure of rather less than 4½ tons per square foot. The saving of masonry, as compared with a solid trapezoidal dam, varies from about 40 per cent. with a 10-ft. dam and masonry of 1.8 specific gravity to about 28 per cent. with a 40-ft. dam having masonry of 2.2 specific gravity. Experiments on models of such dams are also described.

The Reconstruction of Large Sewers in St. Louis, Mo.

The sewerage system of St. Louis is built on the combined plan, the domestic sewage and storm-water run-off being carried to the Mississippi River by the same sewers. Some of the latter were constructed 30 to 40 years ago before the districts which they serve were built up to any extent, and, in cases, where the immediate districts gave no evidence of being developed fully at any future time. Several sections of the city which were almost open country when the main outlet sewers serving them were built, are now congested business or residence districts. As the old sewers were apparently not designed for such conditions, their capacities are consequently now insufficient in many cases. This inadequate capacity of some of the main sewers, and the structural failure of others, has necessitated a large amount of reconstruction on several of the main outlet sewers.



Runways for Handling Excavation and Materials, and Temporary Flume in Reconstructing a St. Louis Sewer.

The Rocky Branch outlet sewer is one of those having an inadequate capacity to carry the storm water reaching it. This sewer serves an area of about 3,500 acres in the closely built-up residence portion of this city where practically all of the streets are paved. The lateral sewers in the area are also largely on comparatively steep grades, the whole combination of conditions tending to bring the storm water to the main outlet very quickly. The latter has a total length of 8,700 ft., the first 2,500 ft. of which from the river is across the low swampy river bottom, the ground rising gradually from this low land to the district served by the outlet sewer.

The outlet sewer for over half a mile from the river has a semi-circular arch, with a clear span of 18 ft., which is carried by haunch walls with vertical faces. The arch consists of four to five rings of brick laid in cement mortar; the haunch walls have cut stone facing backed with rubble masonry.

In constructing the bottom of the sewer, at least, no uniform grade appears to have been followed, as numerous breaks in grade occur in it at uncalled for points. These breaks were introduced at some places, moreover, without similar changes in the grade of the arch. The bottom of the sewer was never lined, nor the natural surface properly leveled. A part of the sewer is on rock and the remainder on soils of different capacities for carrying loads. Where rock foundation occurs the bottom of the sewer was in many places left as the rock was blasted out, with the result that depressions 2 to 7 ft. below grade frequently exist. In soft foundations the haunch walls of the arch were built on heavy logs laid transversely with the sewer. These logs are 18 to 24 in. wide, 8 to 14 in. thick and 18 to 19 ft. long. They are still in a good state of preservation, although the sewer was built in 1870 and the velocity of the sewage over them has been high at various points.

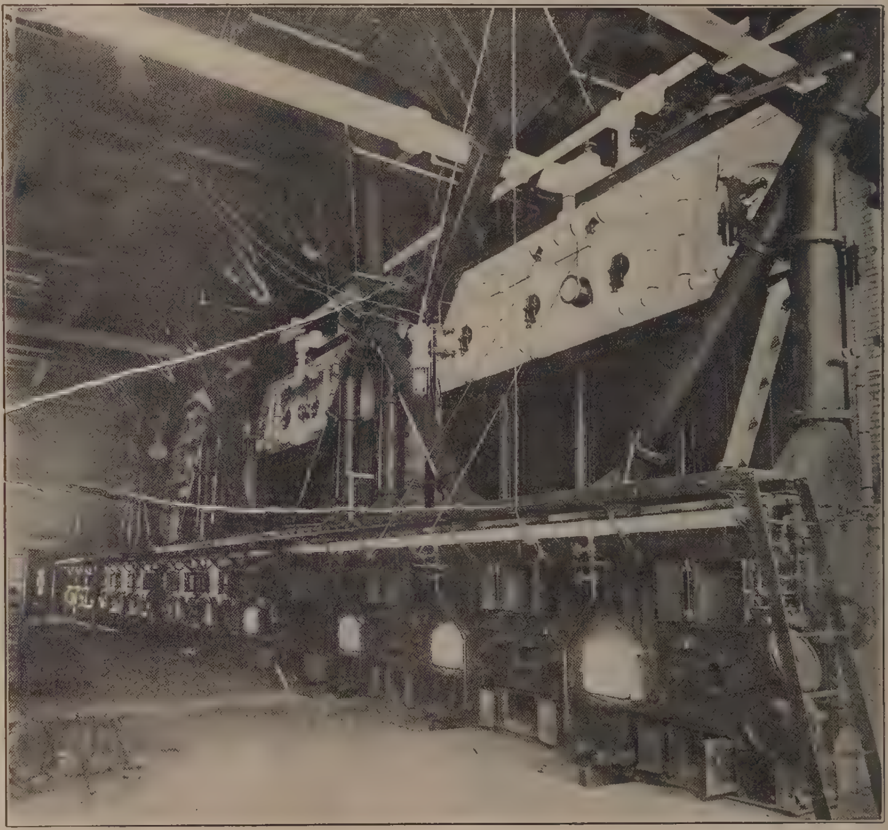
This sewer had become so badly overtaxed that some means of relief for it became an immediate necessity. It is built in a city street for 3,500 ft. back from the river and is of such size that in this distance no room exists in the street for a relief sewer. Furthermore, the soil and other conditions in adjoining parallel streets made the construction of a relief sewer in the latter impracticable. The grade of the bottom of the existing sewer is accordingly being straightened, and the bottom lowered to some extent and lined with an inverted brick arch, with the belief that the carrying capacity of the sewer will be increased in this manner sufficiently to provide for the removal of the flow reaching the sewer. This straightening of the bottom grades required the excavation of 2 to 7 ft. of materials, varying from quicksand to rock and included the logs, where they occurred. The arch ring was also underpinned down to the new bottom level and a new invert placed. Where the sewer was built on rock, this rock was blasted out at the sides, during the original construction, only enough to carry the arch ring, so the excavation made to straighten the bottom grade had to be carried wide enough to provide room for a new haunch walls for the arch.

The work of lowering and straightening the bottom of the sewer was started at the river and carried back for 3,500 ft. to high ground at a point where the sewer leaves the street and passes under private property. From this point a new sewer will be built to relieve the existing one, as conditions are such as to permit the construction of this relief sewer.

During the reconstruction, the dry weather flow reaching the outlet sewer was carried at all times in a wooden flume which was supported, with its bottom on an average of about 6 ft. above the bottom of the sewer, by 12x12-in. transverse timbers having their ends set in the old masonry. This flume had sufficient capacity to carry some storm water in addition to the dry weather flow, but during heavy rains the water filled the lower part of the sewer and covered the work in progress. Much pumping was thus necessitated, and as ground water was encountered in several places while the reconstruction was in progress, the pumps were kept almost continually in service.

For some distance from the river the bottom was largely alluvial deposits, the haunch walls of the sewer as originally built being carried in most of this distance by the heavy transverse timbers. In the reconstruction work, where these timbers occurred the haunch walls were taken out in short sections and the timbers removed. While the excavation necessary to lower or to straighten the grade of the bottom was being made and the brick invert laid, and until masonry underpinning had been carried up to the haunches of the arch from the invert, the arch was carried on shoring on jackscrews. All of this shoring and reconstruction work was handled with much difficulty, some of it being particularly hazardous. Quicksand was encountered for a length of 500 ft. in making the excavation for the new bottom, but the latter was put in as planned in this section, without losing any of the sewer. The work was handled in short sections after the quicksand was encountered, from 4 to 6 ft. being opened at a time. As soon as the timbers were removed and the excavation made, the bottom was sealed with concrete in sacks. Considerable sheeting and much intricate shoring had to be done in all of this work to restrain the quicksand and to support the sewer arch until the concrete seal could be placed.

Rock was encountered in the bottom after the higher ground was reached, and its surface rose faster than the grade of the sewer, so that the lower part of the latter is in excavation in rock at the upper end of the reconstruction work. The sequence of operations after the rock was encountered was generally the same as that followed in the reconstruction in soft ground, except no concrete seal had to be placed in the bottom. The rock was blastetd out as required, small shots being used to avoid injury to the existing masonry and to prevent the disturbance of the shoring supporting the portions of the arch from which the haunch walls were temporarily removed. Where the rock came up on the sides to any extent only enough of it was blasted out to secure a bond for the concrete wall used to underpin the existing wall. The underpinning in all cases was done with concrete, the inside face of the new wall being built out a few inches farther than the inside face of the existing masonry to insure the stability of the latter.



Boiler Room of the Main Power Station at New Orleans.

The blast holes required in excavating the rock were made by Ingersoll Sergeant air drills, supplied with power from a central plant erected by the contractor. This plant contained an Ingersoll-Sergeant compressor belt-driven by a 150-h. p. electric motor, and an alternating current generator furnishing power for lights in the sewer.

Several steam pumps were installed to keep the water level lowered while work was in progress and to pump out the sewer after a heavy rain. These pumps were supplied with steam from the boiler of a derrick outfit which was used in lowering materials into and hoisting them out of the sewer. The excavated materials were hauled to openings in the arch of the sewer on a plank runway laid on the timbers carrying the flume, and the supplies were hauled from these openings to the point where work was in progress in the same manner. The concrete was mixed by hand in the sewer.

The reconstruction of the Mill Creek outlet sewer has also recently been completed in a manner similar to that followed in the work just described. This sewer provides a drainage outlet for 6,000 acres of congested city districts. It has a brick arch, with a clear span of 18 ft., carried by cut-stone haunch walls, the latter being originally built on heavy transverse timbers in the same way as in the Rocky Branch sewer. These old timbers used for the footing and invert began to give way, so a new invert had to be built. The capacity of the sewer being somewhat overtaxed, the new invert was placed 2 ft. below the original bottom formed by the timbers, and was laid at a more uniform grade than the one on which the former had been built.

The haunch walls of this sewer are of first-class cut-stone masonry and the soil through which it is built is for the most part fairly good, so the reconstruction could be carried forward in longer sections than was possible on the Rocky Branch sewer, 32 ft. of the bottom generally being opened up at a time. The timbers being in a good state of preservation, they were chopped off close to the sides of the haunch walls and the part between the walls removed; the excavation for the new invert was then made and the invert built. The latter is of concrete, with a lining of vitrified paving brick, the ends of the old timbers being covered by the concrete.

The dry weather flow in this work was also carried by a flume supported by transverse timbers carried at the ends by the old masonry of the sewer. Since the amount of ground water encountered was much less and the soil conditions considerably better than in the Rocky Branch reconstruction, work was handled with less difficulty.

Mr. H. F. Fardwell is sewer commissioner and Mr. J. A. Hooke is assistant sewer commissioner of St. Louis. The reconstruction of the Rocky Branch sewer was carried on by the Cooney Construction Co. of St. Louis.

The Market Street Station of the New Orleans Railway & Light Company.

One of the advantages of the concentration of public-service undertakings in a city under the control of one organization is the practicability of concentrating the power plants to whatever degree is desirable. This is well shown by the improvements carried out in New Orleans under the direction of Sanderson & Porter, the New York consulting engineers, by the New Orleans Railway & Light Co. When this corporation took over various independent railway, gas and electric properties of that city a few years ago it was at once seen that some of the smaller and less economical power stations could be abandoned to advantage and two of the plants greatly enlarged. A single central station was not desirable, because its construction would have made it necessary to abandon two modern generating stations and because in some areas the distribution of the railway load made it more economical to generate direct current near the points of heavy consumption than to produce alternating current in one central station, with high-tension transmission and conversion to direct current in sub-stations located at the points of consumption. The less likelihood of complete shutdowns in cases of station troubles was another consideration.

Engine Room of the Main Station of the New Orleans Railway & Light Company.

The system as reconstructed comprises one direct-current commercial lighting station and one direct-current railway station in the congested districts, and one large alternating-current station to feed the balance of the territory and the outlying districts. This station also contains 6,000 kw. of direct-current generators for feeding the railway lines in its vicinity. The three stations have an aggregate capacity of 25,000 kw. Sub-stations have been built preparatory to abandoning the small generating plants, over 100 miles of underground conduits have been constructed and a complete new street lighting system, with 3,000 series alternating arc lamps, has been installed. As the load increases and the system is extended additional sub-stations are to be built, and the capacity of the main or alternating-current power station is to be increased up to 50,000 kw. It is not necessary that new generating stations be built until this capacity is reached.

A 2,300-volt and 6,600-volt 60-cycle alternating current and 250-volt and 600-volt direct current are now generated. By means of static transformers between the two alternating-current voltages and motor-generator sets between the alternating and direct current systems the generators in any station may be used to supply current for the commercial or arc lighting or railway services.

The magnitude of the initial and ultimate investment involved for apparatus and the importance of handling the varied services in the most reliable and economical manner were governing factors in settling upon the frequency and voltage characteristics of the generating and distributing systems. The far-reaching importance of correctly establishing these essentials was early recognized, and the decision to adopt a frequency of 60 cycles for the alternating service was finally made as a result of careful deliberation and study of all possible methods. This frequency has been made standard for alternating power required for lighting and railway service. The decision against 25-cycle frequency was based upon the much greater cost of such installation, which would have involved heavy expense for frequency changing apparatus for the large amount of the service requiring 60 cycles and the unsuitability of 25 cycles for the operation of incandescent and arc lamps.

By using only one alternating-current generating frequency the load factor on the station and on the generating units was much improved, with resulting large savings in the cost of generated power, and the idle investment in reserve apparatus was minimized. The large sub-station energy loss which would have resulted from the use of such frequency changes as would have been necessary had 25-cycle generation been adopted was saved by the adoption of a uniform 60-cycle frequency.

It is believed that the higher frequency standard more nearly satisfies all of the present and future requirements and that it will show a decidedly higher all-round efficiency, everything considered, than 25 cycles or a combination of 25-cycle and 60-cycle generation. Furthermore, increase in business is largely dependent upon adopting a system which will involve the least first cost of installation to the consumer. The lesser cost of 60-cycle motors constitutes an important factor, viewed from the standpoint of the operating company.

Sixty-six hundred volts was adopted as being a thoroughly standardized commercial voltage, for which motor generator sets of 50 kw. and upward could be readily wound, so eliminating sub-station transformers. The transmission distances, being relatively short, did not call for a higher voltage than 6,600, which would permit sending the maxi-

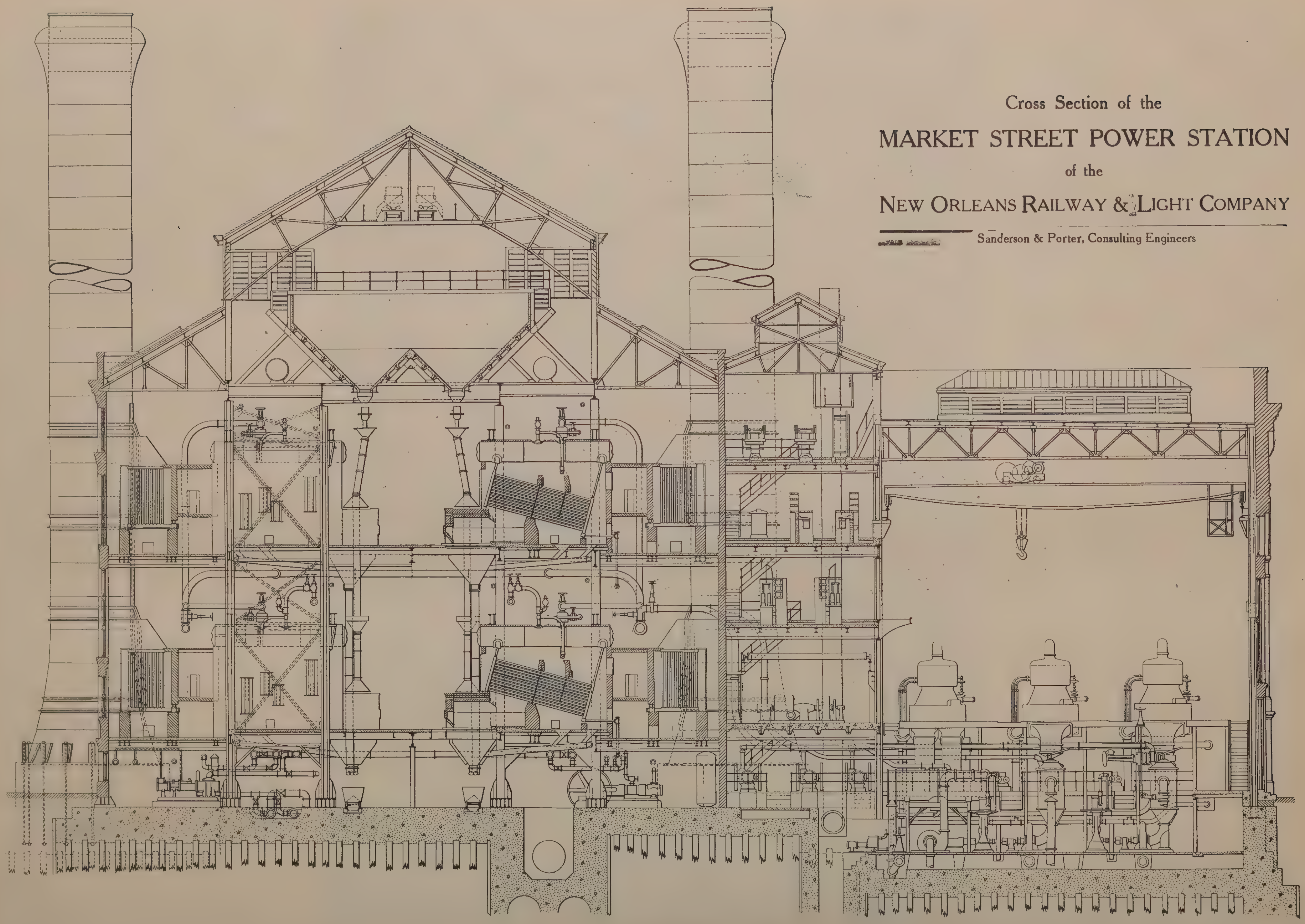
Cross Section of the

MARKET STREET POWER STATION

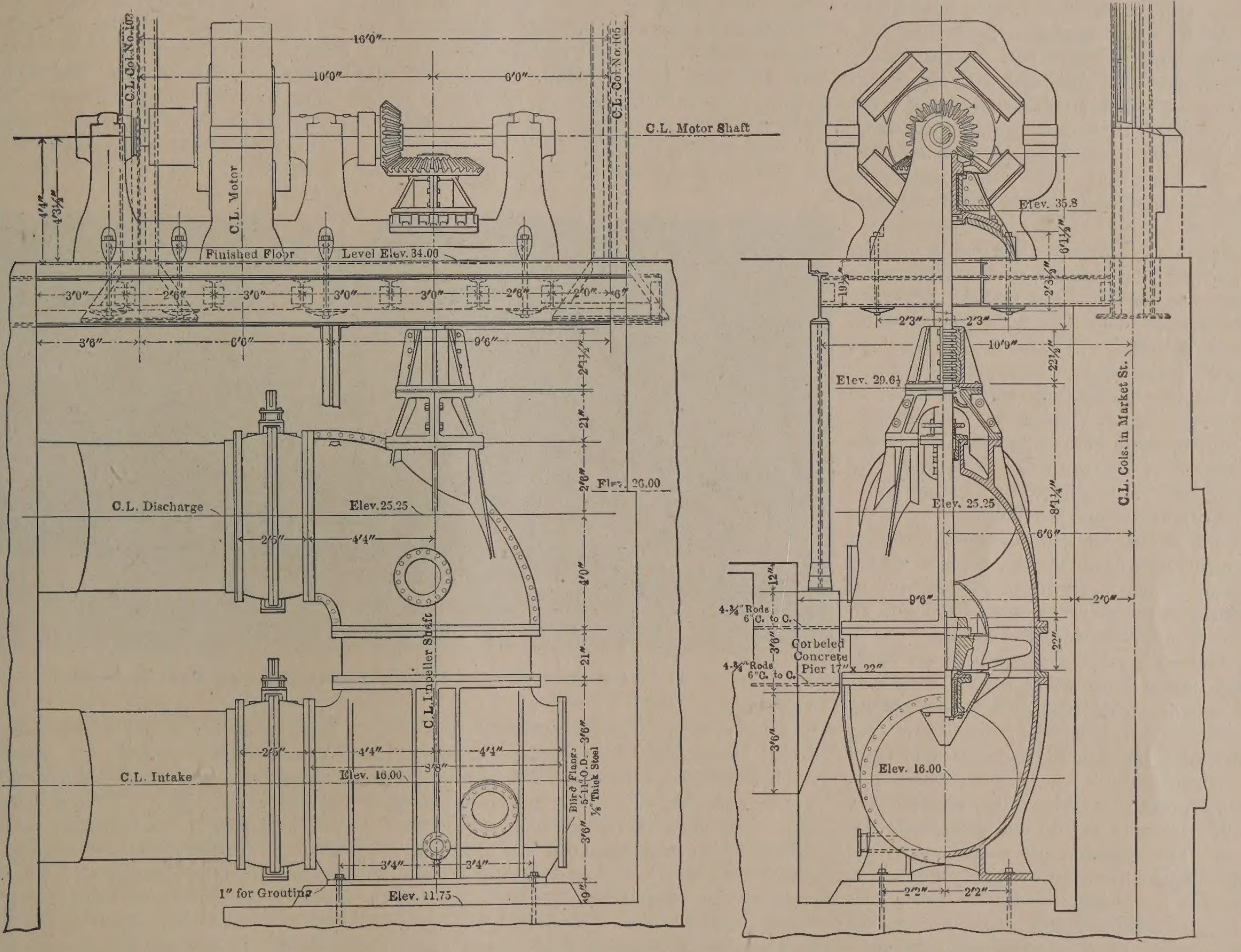
of the

NEW ORLEANS RAILWAY & LIGHT COMPANY

Sanderson & Porter, Consulting Engineers



mum desired amount of energy through any individual feeder with small energy loss. The frequent flooding of the underground conduits by heavy rains, which for short periods may overtax the capacity of the drainage system, rendered expedient the adoption of a moderate voltage, involving no particular difficulties for insulation under these conditions.



Impeller Pump for Flushing Condenser Mains, New Orleans Power Station.

The recent work has involved the construction of practically an entirely new station at Market and South Peters Sts., on the Mississippi River, about two miles upstream from the business center of the city. The station now contains 17,800 kw., and provisions have been made for an ultimate capacity of 50,000 kw. In the "Street Railway Journal" of Sept. 18, 1904, a description of the then existing plant stated that it contained two 2,250-kw. Westinghouse and one 1,500-kw. General Electric railway generating units driven by Allis-Chalmers vertical compound engines, contained in a new building and supplied with steam from boilers in an adjacent old station. The building now forms a portion of the generating room of the new station.

The building is a brick, steel and concrete structure. The portion built measures 181 x 212 ft. and is 122 ft. high. When extended 92 ft., as planned, it will be 273 ft. long. It is supported on approximately 4,000 round piles driven on about 3-ft. centers. The piles are 50 ft. long, and some were set 30 ft. below the surface or were driven to a total penetration of 80 ft. In excavating for foundations and trenches for pipes the surrounding earth was assumed to be of liquid weighing 120 lb. per cubic foot. Excavations were protected by 6-in. grooved piling 30 to 50 ft. in length, with splines measuring 2 x 4 in., to insure alignment and tight joints. Where possible excavating was done by means of an orange-peel digger, and the earth was removed by a tramway. The piles were capped with a reinforced concrete bed approximately 6 ft. thick.

The average load over the entire foundation is something less than 2,000 lb. per square foot, but at points the load concentrated is very much above this figure. At such points twisted steel rods varying in number with the loads were used to reinforce the concrete.

Plans provide for the ultimate installation of four 72-in. pipes to serve as condenser intake and discharge pipes. All four pipes have been extended through the levee, three have been installed under the boiler room and one intake and one discharge pipe have been placed under the railway tracks between the boiler room and the levee. The pipes are made in 30-ft. lengths of ½-in. riveted steel by James McNeil & Bro. Co. and were covered with a protective coating from the American Asphaltum & Rubber Co.

Special provisions have been made for removing sand and silt from the pipes. Water jets supplied with water from a fire pump have been installed at 10-ft. intervals in the bottom of the pipes, and by a system of valves the intake and discharge pipes may be connected at the station end with a propeller type of circulating pump, so located in the connection that a flow of 8 to 10 ft. per second can be produced through the pipes. The pump is driven by a 700-h.-p. 550-volt motor. When the pipes are to be cleaned the jets are first operated to loosen the deposit, and this is then washed out by the flow from the pump. The pipes terminate at the river end in concrete wells, that for the intakes being provided with three sizes of screens.

The building has a steel framework, with brick walls. The roof is of Ludowici and book tile, with a composition top. Bunkers and floors are of reinforced concrete. With regard to steel and roof construction, the building may be said to consist of three parts, the generator room, the double-deck boiler room and an intermediate section occupied by switchboard apparatus, shop and offices and toilet rooms. The adoption of this arrangement permitted the successful execution of the new construction without interference with the operation of units which had to be kept in service. Ample ventilation, important in Southern power plants, is provided by monitors and pivoted windows.

The two steel stacks erected are 15 ft. in diameter and extend 273 ft. above the street level. Both are brick lined to the roof line. Plans provide for the later erection of two additional similar stacks when building is extended.

The present building provides for sixteen 900-h.-p. boilers. Twelve such Babcock & Wilcox water tube units are now installed. They are located on two decks in double rows facing each other and parallel to the generator room wall. They are of forged steel header type, constructed for 200 lb. pressure and are fitted with Babcock & Wilcox bent tube superheaters for 150° superheat. Behind them are Sturtevant economizers, there being one economizer with 4,900 sq. ft. of heating surface to each two boilers. The scrapers of the econmizers are driven by induction motors.

The boiler plant is equipped with thirty-six 300-h.-p. Murphy smokeless furnaces and stokers, set three in a battery under each boiler. Coal is fed to the furnaces through down spouts extending from the overhead bunkers. Provision has been made to later install scales in each down spout. Ashes from the furnaces fall direct into a hopper underneath, while the fine ashes drawn over the bridge wall and the soot accumulation are carried into this hopper by a motor-driven screw conveyor.

Boiler feed water is obtained from two 750-ft. wells, one 6 and one 8 in. in diameter, having a combined capacity of over 1,800 gal. per minute. Water is raised with air furnished by two Ingersoll-Sergeant compressors in the boiler room basement. The water is discharged either into tanks in the basement of the boiler room or into a 60,000-gal. stand-pipe near the building. The boilers are fed by a 1,000-gal. De Laval steam turbine-driven centrifugal pump and three Epping Carpenter pumps, with 16 x 10 x 16-in. cylinders. Connections are arranged so that the water may be forced either through the economizers or direct into the boilers.

A switch extending along the east end of the station contains a 100-ton track scale, and all cars are weighed before and after being unloaded. The cars are run on a sheltered track under the ash bunker at the end of the boiler house and unloaded into a hopper beneath the track. After passing through a crusher provided with an adjustable positive feed the coal is carried by a bucket elevator to the top of the boiler house structure, where it is discharged on a belt conveyor and distributed to any predetermined part of the coal bunkers by an automatic unloader. A 35-h.-p. 550-volt direct-current motor drives the crusher and both belt and bucket conveyor.

The initial coal-handling plant has a capacity of 100 tons per hour, and the plans provide for a duplicate equipment of equal capacity. The initial coal bunkers hold 2,000 tons, and those of the ultimate building will store about 5,000 tons. Additional storage capacity is provided in a vacant lot near the station, coal being conveyed to and from this storage space in electric cars. Dock privileges have been obtained from the city and a portion of the plant for unloading river coal from boats has been erected. This has a rated capacity of 200 tons per hour.

Small side dump cars operating on tracks in the basement underneath the ash hoppers convey the contents of these hoppers to the east end of the building, where the ashes are dumpd into an automatic skip. This skip bucket of 60 cu. ft. capacity hoists the ashes to the top of the boiler room and dumps them into a bunker built over the coal switch. Ashes are discharged by gravity from bunker direct into steam or electric cars and conveyed to the suburbs to be used in track construction or filling.

All high pressure piping is of standard lap weld mild steel, with fittings and valve bodies of cast steel. The high-pressure steam valves are especially designed for use with superheated steam at 200 lb. pressure and have extra long necks at the stuffing boxes. Chapman valves were mainly used, the large ones motor-driven.

The boilers on the upper deck feed through lines passing down behind them into headers running the full length of the boiler room in the rear of those boilers on the lower deck. These headers also receive the steam of the lower deck boilers. Crossover pipes running just underneath the second floor connect the header most distant from the generator room with that one nearest to it, which may be regarded as the main steam header. Steam mains to both reciprocating engines and turbines pass through the boiler room wall and underneath the generator room floor to their respective units.

Connections from the headers behind the boilers drop through the floor to mains supplying the auxiliary apparatus. Extensions continue through the basement wall to serve the engines driving the condenser pumps and other auxiliaries.

In the new portion of the generator room there are installed three 1,500-kw. three-phase 60-cycle 2,300-volt Curtis turbines. A 3,000-kw. and a 500-kw. 6,600-volt turbine of the same make are also provided in the initial building, the former now being in operation and the latter under construction.

Collecting Paper from a Street Rubbish Can in Denver,

One common oiling system, with one accumulator, serves the step bearings of the three smaller turbines. A separate oiling system, with an accumulator, is provided for the two larger turbines. The oil pumps and other auxiliary apparatus, except exciters, are located in the basement.

Three motor-generator sets now operating on other service, each consisting of 500-kw. 2,300-volt synchronous motors and 600-volt direct-current generators are to be installed on the main floor alongside the exciters under the bus structures and will permit transferring 1,500-kw. capacity from either alternating-current or direct-current portion of the station.

Past difficulties in the operation of surface condensers using the silt and clay bearing water of the lower Mississippi River led to the general adoption of Dean and Allis jet condensers on the engines and Alberger jet condensers on three of the turbines. One 1,500-kw. turbine was provided with an experimental, specially designed Alberger surface condenser. The jet condensers of the 1,500-kw. turbines are connected to 12-in. centrifugal pumps and of the 3,000-kw. condenser to a 16-in. pump. All the circulating pumps are driven by single-cylinder Buckeye engines. The turbine condensers are each served by Alberger dry vacuum pumps, which may be run separately or on a common vacuum system.

The exciter equipment already installed consists of an 80-kw. induction motor-driven unit and a 75-kw. unit, driven by a two-stage horizontal Curtis turbine. The exciters are connected to a double bus system, and voltage regulation is effected by a Tirrill regulator built for four exciters. Plans provide for two additional 150-kw. exciter sets, which will be installed near those already in operation on the main floor underneath the switch structure.

The switchboard proper is located on an overhanging balcony at the same height as the second floor of that section of the building between the boiler and generator room. From his position on the balcony the operator has a general view of the entire operating floor. Behind the switchboard are the generator switch and bus structures. On the floor above are similar structures for feeder busses and switches, and there is also located on such floor 2,300-volt regulators for the commercial feeder circuits. On the fourth or top floor is an arc light sub-station. All main and high-tension switches are of the oil break type controlled from the main switchboard by pilot switches. Both generator and feeder bus-bars are in duplicate and all may be sectionalized.

The floors on which the switch-control apparatus is located are constructed with a view of facilitating repairs should it ever become necessary to get at the cable or conduits. The I-beams support a 6-in. solid concrete floor. On this is a 11-in. loose filling, in which the conduits are laid, this being covered with a 4-in. concrete floor.

The bus and cell structures are built in groups, with the main and auxiliary bus structures flanking a common passageway on the second floor, and the feeder bus structures similarly arranged on the third floor. The structures are of concrete, with the exception that the tops and bottoms of the generator and sectionalizing switch compartments are of Alberene stone. The structures are reinforced by iron rods running through the barriers from top to bottom. The generator leads are carried down under the generator room floor from the generator terminals to junction boxes and then up the building columns in brass conduit direct to the generator switches of the main generator and auxiliary busses. A group switch connects the 2,300-volt main generator bus to a main feeder bus on the floor above, and a similar switch connects the generator auxiliary bus with an emergency feeder bus. The 6,600-volt generator and auxiliary busses are permanently connected to extensions of these busses in structures on the floor above and from which the feeders are taken off. The 6,600-volt and the 2,300-volt bus systems are connected by two 1,500-kw. oil-insulated water-cooled three-phase transformers, located in the basement.

The generator control panels are located at the west end of the initial switchboard, the plans providing for the installation of 6,600-volt feeder panels west of them, so that they will be centrally located with respect to the ultimate switchboard. To the east of the generator panels are exciter and house service panels and space for three synchronous motors and three railway generator panels.

The space east of the switchboard and bus structures is devoted to offices, a machine shop, toilet and wash rooms, which contain needle baths and porcelain finish wash troughs, supplied with hot and cold water, and are furnished with expanded metal lockers. Separate toilet and wash rooms are provided for the colored firemen.

General lighting of the generator room is effected by arc lamps supported on wall brackets. The boiler room and switchboard structure are lighted with incandescent lamps.

A STORAGE HOUSE FOR RECORDS, documents and valuable papers is being planned by the Pennsylvania Lines West of Pittsburg, according to a recent report. At the present time a great many valuable papers are stored in the offices of the various divisions in buildings which are often far from fireproof. In order to remove the danger of loss by fire, it is proposed to erect a large fireproof building in Pittsburg where the records from all parts of the system west of that point could be filed and cared for.

Street Cleaning in Denver, Col.

Street-cleaning operations in Denver have been developed along lines somewhat different from those followed in most cities in this country. The streets in the central portion of the city are paved with asphalt, over twenty-five miles of this pavement having been laid. The remainder of the total thirty-five miles of paved streets are paved with sandstone block, and, in addition, nearly twelve miles have been macadamized. A considerable mileage of the balance of the streets are surfaced with gravel, and are provided with curb and gutters. All of these improved streets are cleaned regularly, at intervals depending entirely on the density of the traffic tributary to them.

A large percentage of the street traffic in Denver, and particularly of the horse-drawn vehicles, is over the asphalt streets. Consequently, a major portion of the activities of the street-cleaning department of the city is devoted to these streets. Rotary sweeping machines, each mounted on a four-wheel truck drawn by a team of horses, are used to collect in furrows the principal part of the detrius on the asphalt. These machines are followed by automatic pick-up machines, also mounted on a four-wheel truck drawn by a pair of horses, which collect practically all of the material placed in the furrows by the sweepers. When the weather is propitious, the street over which the pick-up machines has just passed is thoroughly washed with sanitary flush-tank wagons, built especially for this purpose. These flushing wagons are followed closely, in turn, by men with brooms, who sweep into the storm water sewers such water, refuse and fine particles of material as remain. All of this work is done during the day, the heavily-traveled streets being cleaned first. After the sweepers have passed, block men with brooms and two-wheel push carts continue the removal of refuse the balance of the day.

The operation of the rotary sweeping machines during the day, without delivering a continuous cloud of dust to interfere with traffic on the streets, or with pedestrians, is rendered possible by several changes which have been made in the construction of these machines. The most important of these changes, so far as avoiding an obnoxious cloud of dust is concerned, has been the extension of the tight wooden deck over the machines so two heavy canvas hoods can be placed around the machine, instead of a single hood, as is usual. The two hoods are arranged so an air space of about 5 in. is provided between them. This enclosed air space quite effectually intercepts all of the dust that passes under, or through the inner hood, with the result that the sweepers thus equipped are regularly operated in the daytime, without complaint from the merchants and residents along the streets, or from pedestrians. This ability to do all of the sweeping in daylight has greatly increased the efficiency of the street cleaning forces, and reduced the cost of the work, as compared with the efficiency and cost when the work was done at night.

The refuse collected by the block men with brooms and push carts is placed in 3-yd. boxes, placed at convenient intervals in the alleys. The alleys in the business district are also cleaned daily and the refuse placed in these boxes, which are emptied into wagons each day.

A sanitary rubbish can of special design, which has been used for about two years in the business district, has proved particularly effectual in obtaining the assistance of pedestrians to keep paper, fruit skins and similar litter off the streets. Prior to the use of these special cans ordinary round garbage cans were placed at the street corners and other points, as the receptacles for this litter. The records of the street-cleaning department show that these original cans enabled much of the refuse and litter formerly cast into the streets to be collected. Soon after the installation of the new cans the amount of material thus collected was doubled and is now more than three times what it was with the old cans. This condition can probably be attributed, more than anything else, to the attractive appearance of the new cans, which are at the same time built to be specially adapted for service.

The body of each can is 36 in. high and 19 in. square, with a frame of light steel angles and sides of sheet iron, the bottom being open. A leg, consisting of a short piece of steel angle, is placed under each of the four corners; these legs are adjustable in height so the can may be set in an upright position on a slanting sidewalk. The cans are designed to be attached to an angle-iron post set in the sidewalk. Some of the cans which have been installed were built with a vertical depression in the middle of one side, in order that the can might be attached to the angle-iron post in a minimum space. Some few of the cans are also attached to trolley wire posts of the street railway.

The top of the can is an inverted hopper, with a wide-mouth opening, and is not hinged to the body. A groove along one side of it fits over a projection on the inside of the body in such a manner that when a hasp on the opposite side of the top is attached to a fastening on the outside of the can by a padlock, the top cannot be removed. The wide opening in the top, together with the trim form and the fact that each can is painted a silver gray, with nothing but the words "Rubbish and Paper" on them, appear to be the chief features which attract attention to the object of the can.

A burlap sack, which just fits the interior of the can, suspended from a row of hooks around the sides of the top of the body. The top edge of this sack is provided with eyelets which fit over the hooks. The latter are placed directly under the removable top, so the the sack cannot be taken out as long as the top is in place. The bottom of the sack is perforated to permit the escape of moisture, and as the can is built without a bottom, a free circulation occurs through the contents, keeping them as nearly dry as possible.

The removal of the filled sacks, without causing any dust and without losing any of the contents, is readily accomplished by a simple arrangement. A rope is threaded through the eyelets in the sack so the top of the latter can be drawn together and tied before it is pulled out of the can. An empty sack is then placed in the can and the filled one loaded on a wagon which makes regular collections. In all, 276 of these cans have been installed, and when making a collection three times a week the large rack wagon, shown in the accompanying illustration, is completely filled at each collection under normal conditions. The average load at each of these collections is about 2,400 lb.

The macadam streets in the residence districts of the city are swept regularly and the gutters of the surfaced streets are cleaned by a combined sweeper and sprinkler. The paved alleys in these districts are cleaned three times each week.

The equipment of the street cleaning department is housed in sheds adjacent to the business district. A shop in which all of the equipment is kept in repair is maintained in connection with these sheds. The rotary sweeping machines were built, and the pick-up machines were rebuilt in the shop, according to plans of the department.

The department has 90 men in its employ, regularly maintaining four sweeping outfits, which each include a rotary sweeper and a pick-up machine, with five men and a foreman to each outfit; another man and team are also added to the outfits at work on asphalt streets when flushing is done. Forty-five block men, with brooms and push carts are kept at work, the territory covered by each man depending on the traffic. The expenses of the department for the year of 1906 were $81,482.55, of which over $6,000 was for the establishment of the new plant and $8,454 for new equipment.

The department is under the supervision of Mr. Samuel L. Phillips, commissioner of highways, of Denver, to whom this journel is indebted for the information from which the foregoing notes have been prepared.

Book Notes.

About seven years ago Mr. Thomas Aitken, surveyor to the County Council of Fife, wrote a book on "Road Making and Maintenance," which is one of the best practical manuals on work of this sort in Great Britain. Since it appeared there has been a considerable change in many branches of road work. The automobile has demonstrated its devastating powers on roadways, new types of wood pavement have been introduced, tarring has pushed its way to the forefront, and the author himself has taken a prominent part in the widespread movement to prevent dust. A new edition of the book has accordingly been prepared to agree with the changed conditions. It has the same practical character as the first edition and will be found of much interest to American engineers who wish to secure information concerning the many British novelties in methods and plans which are attracting attention there but seem to be strangely belated in appearing on this side of the Atlantic. (London, Charles Griffin & Co., Ltd., 21s.).

One of the most perfect books typographically that has appeared in this country is the translation by Brother Arnold, principal of La Salle Institute, Troy, of the "Letters of Petrus Peregrinus on the Magnet." The author, a friend of Roger Bacon, was a highly educated French military engineer, who wrote his famous letters in 1269, thus making the first important contribution to magnetic philosophy, the next being the "De Magnete" of Gilbert in 1600. There are a dozen or so ancient manuscript copies of this letter in European libraries, and a copy of the first printed edition, that of 1558, is in the Wheeler Collection of the library of the American Institute of Electrical Engineers. This translation has been made with a scholarly accuracy and literary grace that are charming, and a similar satisfactory introduction concerning the author and his letter has been written by Brother Potamian, of Manhattan College. The great importance of this letter and the exceptional character of its translation and introductory notice led the publishers to give the book a form that was similarly perfect. A large amount of study and experiment was put on the task, and it is believed that nothing has yet been done in this country which is any better, the result being a unique volume of interest equally to those who wish to know about the very beginnings of electrical knowledge, and to bibliophiles. (New York, McGraw Publishing Co., $1.50.)

The first volume of Dr. S. Dunkerley's "Hydraulics" is somewhat disappointing, because it is by no means as good a work on the subject as the author is able to write, and, moreover, it contains typographical and other inaccuracies that are annoying. The first chapter is a discussion of the flow of a perfect fluid through orifices, jets and notches, and the second discusses fluid friction, practical formulas for the flow of water, steam gauging and allied subjects. The chapter has a short article on water meters in which American meters receive very snippy notice, which is rather surprising in view of the favor with which they are regarded in Europe. The third chapter is a description of hydraulic pressure machines; the elevators of the Eiffel tower are given among the examples of such machines, but the latest patterns of apparatus designed by the same builders, the Otis Co., are overlooked. This is a pity, for elevator machines of the hydraulic type have revolutionized the possibilities of office-building construction and their details are of unusual interest. In the chapter on reciprocating pumps, which comes next, the main interest will probably be found in the discussion of the theory of air chambers, although there is a long description of the Gutermuth spring valve for water chambers, a German novelty. The fifth chapter is on turbines, and the sixth is on centrifugal pumps; in each the theoretical principles are first outlined and then apparatus is described, special attention being drawn to compound turbines and pumps built under the direction of Prof. Osborne Reynolds some twenty years ago. The seventh and final chapter is a review of that scientist's researches in viscous flow and the theory of lubrication. It must not be inferred from what has been stated that the book is not a useful one, for it is one of the best resumés of British research in hydraulics that has yet appeared. Its defects, outside of the poor proof-reading, lie in the references to machinery that can hardly be considered typical of the state of engineering at present. (New York, Longmans, Green & Co., $3.00.)

Letters to the Editor.

Metric Curves.

Sir: Enclosed find a few rules for reducing English curve values to metric. These were deduced for the purpose of platting metric curves, and are not applicable to field work as the values given are not exact. They vary on the same principle that the radius of a 2° curve is not exactly one-half that of a 1° curve, nevertheless they are sufficiently accurate for most purposes of platting, and may interest some of your readers. A table giving the radii, arcs and tangent distances in English values is required for their use.

The basis of the metric curve is: A twenty-meter chord subtends one degree of central angle.

To find the radius: From an English table find the radius of a curve of one-half the degree of the required metric curve, and point off one place; this is the radius of the required metric curve. Required to find the radius of a 5° metric curve: 5° ÷ 2 = 2° 30′. R. 2° 30′ = 2292.01. 229.20 is approximately the radius of a 5° metric curve.

To find the S. T. From an English table find the S. T. for the given central angle, but for a curve of one-half the given degree, and point off one place.

To find the arc or length of curve: From an English table find the arc for the given central angle, but for a curve of one-half the given degree, and point off one place.

The above values may be reduced for English to metric, by multiplying the English value by .2, or dividing by 5.

Yours respectfully,

Geo. E. Winton.

Merced, Cal., Nov. 17.

[This relation is pointed out as follows by Professor C. F. Allen in his "Field and Office Tables": "The radius, the chord, length, offset, or other linear dimensions on the metric curve will be 0.2 that of U. S. curves of double the degree or nearly 0.1 those of U. S. curves of the same degree." Professor Allen here takes the degree of curve in the metric system as the deflection angle for a chord of 20 meters, whereas in the above letter it is taken as the angle subtended at the center by a chord of 20 meters. The two formulas, therefore, give similar results.—Editor.]

Heating and Ventilation.

Sir: Your editorial of Oct. 26 and the letter of Mr. Walter B. Snow of Oct. 31 I consider very much to the point, and feel that you and he have done one phase of mechanical engineering a service by calling attention to a situation that requires improvement. It is a fact that most heating and ventilating work of the present day, though not by any means all, is done on rule of thumb methods but little removed from the ordinary work of the skilled mechanic, and such mistakes as develop are either left in or corrected after the installation has been completed. This has permitted men who are little more than steam fitters to pose as mechanical engineers engaged in heating and ventilating as a branch of mechanical engineering, much to the detriment of the work done and to the standing of the profession, the purchaser or owner paying for the mistakes. There are many prominent exceptions to this, as in every line, and those engaged in this work can no doubt name colleagues who have become scientific engineers without ever having seen a college, but such men rose only through natural ability and effort impossible for the average. This situation has arisen largely through the absence of scientific data, but largely also through the ignorance of the existence of such data as there is, on the part of those engaged in the work.

It is the function of the schools of mechanical engineering primarily to teach students what there is known on any particular appropriate subject so far as possible and to extend the knowledge of that subject by research work. Heating and ventilation as a profession is not at this time recognized in any school of good standing in this country and it is an open question whether the time has not come to so consider it. That it is a branch of work capable of scientific treatment and of importance to the general public health admits of no question. It is, however, only one branch of that most broad and scientific department of engineering commonly known as "mechanical engineering," and as such, and by reason of its importance, should receive some treatment in a course of mechanical engineering. It is an error to assume that any such course, however thorough it maybe in its fundamental training on heat, applied thermodynamics, mathematics, physics and chemistry and steam machinery as taught in the laboratory, drafting-room and class, which contains no treatment of the methods of applying this knowledge to the problems of heating and ventilation or the analysis of these problems into the fundamental elements, is a sufficient preparation for its practice. The analysis of practical heating and ventilating problems in as great a variety as possible, into their elements, all of which elements are contained and covered in any good course of mechanical engineering, is just as much necessary as the proper teaching of these basic subjects. Any course of instruction laid out with the idea of teaching the practice of heating and ventilation in the shortest time and of teaching nothing else would be entirely too narrow to be dignified by the name of a profession or to be of much use to the engineer who must keep up to date and lead in the solution of new problems.

It would seem that the best preparation for the practice of heating and ventilation would be a course in mechanical engineering to which was added, or which included, an examination of heating and ventilation problems and their analysis into the elements that are included in every course in mechanical engineering. Thus would be laid down a scientific basis as broad and many-sided as anyone could desire. There would be lacking, however, in the man thus prepared the ability to approach in a practical way a heating and ventilation proposition; he would not have much knowledge of costs of materials, labor or fixed charges or how to use them; he would not have much knowledge of the necessity for the exercise of ingenuity in locating his pipes and conduits, his heating surface, his returns, fans, fittings and regulators to those spaces left by the architects for the purpose, nor would he be able to surpervise the installation of a system because he would not know good work from bad. Such practical knowledge as this, however, cannot be taught entirely in the schools. It must be learned in the doing, and with the sort of preparation laid down above should be quickly learned. After the completion of an ordinary four-year course in mechanical engineering, a simple way of acquiring much that is practical and special in heating and ventilation would be the pursuit of a fifth year combining the present methods of instruction with practice of some of the art schools. In the fifth year the student can listen to lectures by prominent specialists on various phases of the subject, for, say, half his time or full time on alternate weeks and spend the rest of his time in the business office estimating and analyzing costs, in the drafting-room making layouts, and in the field assisting in the supervision of installations; he would at the end of that time be very much farther along toward becoming a useful heating and ventilating engineer than if he had spent two years at the practical work alone or a similar time additional in the college.

Mechanical engineering has split up into many specialties besides heating and ventilation, such as the powering of ships, mechanical refrigeration and ice-making, the management of factories, the design, construction and operation of power plants, and special machinery for elevating and conveying, pumping, air compression, crushing and grinding, the manufacture of cement and plaster, brick, textile and paper, the construction and use of machine tools and hosts of others, all demanding recognition. In the present four-year course we find it difficult to teach properly even those things that may be considered most broadly fundamental and necessary to all branches of mechanical engineering. How then are the schools going to face the problem of teaching these specialties as they should be taught? The method that will probably be the most feasible is the fifth year, not devoted entirely to the school, but spent partly in the school and partly in the field after the four years' work, in which special application can be effectively made without narrowness.

Yours very truly,

Charles E. Lucke.

Columbia Univ., Nov. 29.

The Iron Ore Production in the United States during the fiscal year 1906 is stated by the U. S. Geological Survey to have been 47,750,000 gross tons, valued at $100,597,000. This is an increase of about 12¼ per cent. in tonnage and nearly 34 per cent. in value over the production for 1905. Minnesota furnished ore valued at nearly $52,000,000 in 1906 and Michigan produced an output valued at $31,000,000. Alabama ranked third with an output valued at a little over $5,000,000. The larger part of the ore was mined directly by companies using it in their own furnaces.